FINAL REPORT OF THE NATIONAL PARK MARINE DEBRIS MONITORING PROGRAM

1993 Marine Debris Surveys: With a summary of data from 1988-1993

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FINAL REPORT OF THE NATIONAL PARK MARINE DEBRIS MONITORING PROGRAM

1993 Marine Debris Surveys: With a summary of data from 1988-1993

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CONTENTS

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SUMMARY

The National Park Service, the National Marine Fisheries Service, and the U.S. Environmental Protection Agency cooperated in a five-year study to quantitatively assess the abundance, composition, and accumulation of marine debris on national park beaches on the Atlantic, Gulf of Mexico, and Pacific coasts, and the U.S. Virgin Islands. This study, the National Park Service Marine Debris Monitoring Program, was the first comprehensive analysis of marine debris in the United States. This report summarizes the survey results of the fifth and final year (1992-93) of the program. In addition, the report includes a summary of the cumulative results of the five years of the program.

During 1992-93, quarterly surveys were conducted on thirty-six beaches at seven national park units: Olympic National Park, Channel Islands National Park, Gulf Islands National Seashore, Canaveral National Seashore, Cape Hatteras National Seashore, Assateague Island National Seashore and Cape Cod National Seashore. These seven parks completed their fifth year of surveys. Two parks, Dry Tortugas National Park and Virgin Islands National Park, completed their second year in the program. Padre Island National Seashore finished its second year of surveys under a revised methodology. Data from Padre Island, Dry Tortugas and Virgin Islands are analyzed separately in the report.

The 1992-93 surveys recorded a total of 115,065 debris items for the seven national park units. Most debris found were plastic (95%), consisting largely of fragments. The average quarterly debris accumulation rates for all debris ranged from 2,028 items/km at Olympic National Park to 175 items/km at Assateague Island National Seashore; the national average for the seven parks was 906 items/km. Debris composition differed among the parks: Cape Cod National Seashore continued to have the greatest percentage of plastic fishing debris (e.g., floats and nets), whereas Gulf Islands National Seashore and Assateague Island National Seashore had the lowest percentage of plastic compared to their total

amount of debris (83% and 84%, respectively). Seasonal differences were found in the accumulation of plastic debris, with more debris usually found during the winter surveys and less during the spring (although sample sizes differed). Plastic items that could be ingested by marine animals (e.g., foam fragments) were about 41 times more abundant than items posing entanglement hazards (e.g., rope or nets) (515 versus 13 items/km beach). Glass was the most abundant nonplastic debris category. Medical debris was found in very low numbers (only 145 items [0.12%] for all seven parks during the year).

The results for the 1992-93 surveys for the seven parks were similar to those that were recorded in the previous four years. The average quarterly debris (plastic and nonplastic) accumulation rates for all seven parks increased over the first four-year period (820 items/km in 1988-89, 842 items/km in 1989-90, 915 items/km in 1990-91, 922 items/km in 1991-92), but decreased slightly (906 items/km) in 1992-93. High variability in the data, however, precluded a statistical assessment of trends. Only at Olympic National Park did average quarterly accumulation rates increase each year. The other six parks exhibited both increases and decreases between years, although Channel Islands National Park and Assateague Island National Seashore each showed a three-year pattern of declining accumulation rates.

In 1992-93, Padre Island National Seashore reported a total of 20,441 items collected from six survey beaches. Most of the debris items (93%) were plastic, and miscellaneous plastic items predominated (70%). At Virgin Islands National Park most of the debris items collected were plastic (84%). Miscellaneous plastic debris was the predominate item (42%). At Dry Tortugas National Park most debris items were plastic (71%), with miscellaneous debris predominating (54%). For each of these three parks, miscellaneous plastic debris was primarily composed of fragments of foam and hard plastic.

Over the five years of the program, plastics comprised the majority of debris found at all seven parks. The average quarterly accumulation rate for plastic debris increased by 21% between 1988-89 and 1992-93 (711 items/km to 860 items/km). The ten most abundant plastic debris items over the five-year period were: foam fragments, hard plastic fragments, caps and lids, rope <1 m, bottles <1 gallon, bags <1 m^2, straws, plastic sheets <1m^2, balloons, and miscellaneous packaging.

Foam and hard plastic fragments comprised the largest portion of the debris during the five-year survey. Removal of fragments from the analysis results in significant changes in plastic debris composition. By excluding fragments, miscellaneous items fall to third place in abundance behind packaging and fishing items, respectively. Plastic, however, remains the predominant debris type, even with removal of fragments from the analysis.

Debris accumulation varied considerably between years for all parks. Debris accumulation appears to be a stochastic process driven by storms, human activities, and other unpredictable events. Beach attributes, ocean currents, proximity to urban and fishing centers, ports, shipping lanes, and military installations probably also influenced observed patterns.

INTRODUCTION

The amount of human-made debris found on beaches and at sea has become a concern in the United States and other parts of the world (National Academy of Sciences 1975; Hellenic Marine Environmental Protection Association 1990). Debris washed ashore diminishes the scenic and recreational value of beaches; while adrift at sea, debris endangers marine wildlife. Of particular concern is plastic debris, which can entangle or be ingested by marine mammals, seabirds, fish, and sea turtles (Cottingham 1988). One estimate is that 56% of all remaining, highly- endangered right whales (*Eubalaena glacialis*) show some evidence of entanglement scars (Cottingham 1988). A recent study in Florida noted that over 14% of dead manatees (*Trichechus manatus latirostris*) had plastic debris in their gastrointestinal tract (Beck and Barros 1991).

The ubiquity of marine debris has become more evident. Papers presented at the recent Third International Conference on Marine Debris (Miami, Florida, May 1994) documented debris from all areas of the world. A study in the north-central Gulf of Mexico found large amounts of plastic debris in every study site year- round (Lecke-Mitchell and Mullin 1992). Studies in coastal Georgia (Gilligan et al. 1992) and Nova Scotia (Lucas 1992) noted that plastics were the predominant type of debris collected. Ross et al. (1991) determined that 62% of shoreline debris in Halifax, Nova Scotia, came from recreation and land sources. Marine debris has been found in the North Sea (Dixon and Dixon 1983) and in the Mediterranean (Shiber 1987). Plastic debris and tarballs were found to be the most common contaminants in the Cape Basin region of the south Atlantic (Morris 1980). In southeast Asia, enough marine debris was appearing along the shorelines of Indonesia to cause concern for the tourism industry (Willoughby 1986). The problem of marine debris in Indonesia has forced subsistence fishermen to modify fishing behavior (Nash 1992).

Coastal beaches are especially suited for monitoring changes in the suspended marine debris load because they provide accessible, dynamic platforms for accumulation. In Alaska, the National Marine Fisheries Service has monitored derelict fishing gear and other entangling debris on remote beaches since 1972 (Merrell 1984; Johnson and Merrell 1988). For the remainder of the country, the problem of beach debris has been perceived largely as aesthetic and human health problems. More recently, data on the types and quantities of debris on beaches in the continental United States have been collected from volunteer beach cleanups (Hodge et al. 1993).

In 1987, the United States ratified Annex V of the protocol relating to the International Convention for the Prevention of Pollution from Ships (MARPOL). Among other things, Annex V specifically prohibits the at-sea disposal of plastics.

In an effort to learn more about the amounts and types of plastic debris littering our beaches, and especially those debris items which pose hazards to wildlife, the National Park Service and the National Marine Fisheries Service launched a five-year National Park Marine Debris Monitoring Program. Using survey methods developed by the National Marine Fisheries Service (Johnson 1989), eight national park units (Olympic and Channel Islands National Parks, and Padre Island, Gulf Islands, Cape Hatteras, Assateague, Canaveral, and Cape Cod National Seashores) were selected by geographic coastal region to participate in marine debris monitoring for the past five years. Two additional sites, Virgin Islands and Dry Tortugas National Parks, were added in the fourth year (1991-92), with support from the Environmental Protection Agency and the National Marine Fisheries Service.

Through quarterly surveys of established beaches, the National Park Marine Debris Monitoring Program has gathered data to evaluate marine debris on U.S. beaches (Cole et al. 1990, Manski et al. 1991, Cole et al. 1992, Cole et al. 1995). The objective has been to provide a quantitative assessment of trends in marine debris abundance, composition, and accumulation at the sites. In addition to these surveys, a pilot program at Padre Island National Seashore is assessing lateral movement of debris and is conducting daily surveys versus the quarterly surveys conducted at the other parks (Miller 1993). This pilot program is providing valuable comparative data on the two methodologies.

This report summarizes the results of the fifth and final year (1992-93) of beach surveys for seven parks--Olympic, Channel Islands, Gulf Islands, Canaveral, Cape Hatteras, Assateague, and Cape Cod. Two additional parks, Virgin Islands and Dry Tortugas, completed their second year in the program and the data are evaluated in this report. Data from surveys conducted at Padre Island National Seashore under a revised methodology are also included. In addition, this report includes a summary of the cumulative results of the five years of the program with an overview of changes in types and accumulation of debris by park, year, season, and individual survey beaches.

METHODS

Ten national park units participated in the fifth year of the National Park Marine Debris Monitoring Program in 1992-93 (Figure 1).

The Pacific coast was represented by Olympic National Park in Washington and Channel Islands National Park in California. Padre Island National Seashore in Texas, Gulf Islands National Seashore in Mississippi and Florida, and Dry Tortugas National Park (located west of Key West, Florida) represented the Gulf of Mexico. Virgin Islands National Park illustrated the Caribbean region while Canaveral National Seashore in Florida and Cape Hatteras National Seashore in North Carolina represented the southern Atlantic coast. The northern Atlantic coast was represented by Assateague Island National Seashore in Maryland and Virginia and Cape Cod National Seashore in Massachusetts.

Sampling Protocol

Marine debris was sampled quarterly (Decem ber, March, June, September) at all parks, usually along five 1-km study beaches, using similar methods except as noted. Survey beaches were not chosen at random but were selected based upon similarity among beaches, remoteness, and access. All human-generated debris (except wood) visible from a walking height and greater than about 5 mm in size was recorded on data sheets (see Appendix A for sample data sheet and Appendix B for debris definitions). During each survey, debris was either removed from beaches or marked with fluorescent paint or tags; marked items were not counted on subsequent surveys. Debris was recorded either while conducting the survey or tallied off-site. The survey area of each beach extended from the water's edge to the seaward limit of terrestrial vegetation or, if the vegetation was not apparent, to the base of the foredune.

Items were considered "fragments" if they were less than one-half their presumed original size. Netting with less than five complete meshes was also regarded as a "fragment." Debris entangled in a clump containing many distinct items was tallied individually only if it was not originally attached to other items. Attached items that were originally a functional unit were not recorded separately (e.g., a rope connected to a float was classified as a float). Plastic items considered an entanglement hazard to animals included rope $\geq$1 m in length, netting (trawl web and multi- and monofilament gill-net), loops of rope, monofilament fishing line, rings/gaskets, six-pack yokes, and closed packing straps. Plastic debris that was considered a potential ingestion hazard to animals included foam fragments, plastic bags, plastic sheeting, balloons, and condoms. Tampon applicators, cotton swab sticks, and condoms were considered to be indicative of sewage-related debris. However, only tampon applicators were used in an analysis of sewage debris, as data for the other two items were not collected during the first three years. Condoms, syringes, and saline bags were considered medical/health related items. Three items, pipe thread protectors, write protection rings, and hardhats, were added in the fourth year as an index of debris from the oil and gas industry.

A mean accumulation rate (number of items/km beach/quarter) was calculated for each debris category and served as the basis for producing all park and national data summaries and figures. (In certain instances--e.g., nesting by federally threatened shorebirds--only part of a survey beach was accessible to sampling. In those cases, three 100 m beach sections were cleared. During the next survey, those same three beach sections were sampled, but then the entire beach was cleared. The two consecutive survey dates were thus comparable, and the beach had been cleared for ensuing surveys.) Accumulation rates were assumed to be minimal values because the methodology called for sampling only one day for every three months. Debris items washing ashore in the interim were often removed by tides or buried, and thus were not counted. The relative abundance and composition of debris was analyzed by category (fishing, packaging, personal, and miscellaneous), season, and location. Debris recorded quarterly (December, March, June, and September) was regarded as representing fall, winter, spring, and summer, respectively. Plastic items at each park were ranked according to their abundance (mean number/km of beach/quarter); a list of the ten most abundant plastic debris items was developed by summing the individual park ranks.

For analysis of the five-year survey data (1988-93), all the years were combined for each park and the mean number of debris items/km/quarter was again used as the basis of comparison. Data from Padre Island National Seashore, Virgin Islands National Park, and Dry Tortugas National Park are not included in the determination of national averages. Data for Virgin Islands and Dry Tortugas had not been collected in all previous years and data for Padre Island were collected using a non-standard methodology. For calculating the percentages, total sums of debris were used. The top ten ranked plastic debris items during the five years were determined on a mean number/km/quarter basis.

The data presented have been rounded to the closest whole number. Quantities of less than 0.5 items/km of beach/quarter are referred to as trace [TR].

Study Areas

Pacific Coast

Olympic National Park

The 91-km coastline of Olympic National Park is one of the few remaining undeveloped areas along the Pacific coast (Figure 2). The five 1-km survey beaches are at locations with relatively easy access and meet the sampling criteria. All survey beaches have gentle-to-moderate slopes and predominantly sand and gravel substrate. On some beaches, the extreme high-tide zone is frequently covered with large amounts of drift logs. These areas collect much larger volumes of litter than areas of open beach. Drift log areas do not always remain constant from one year to the next or even from one winter storm to the next. Summer currents move predominantly north-south, whereas winter currents are primarily south-north. The trans-Pacific Japanese Current is the main influence on coastal processes and climate.

The five 1-km beaches were sampled December 8-15, 1992, and March 13-21, May 25-June 20, and September 8-15, 1993. One to four persons surveyed the beaches each quarter.

Channel Islands National Park

Channel Islands National Park consists of five islands and the surrounding marine ecosystems off the southern California coast (Figure 3). The islands range in size from 260 to 100,000 hectares. Survey beaches, located on Santa Rosa Island (21,450 ha) and San Miguel Island (4,047 ha), are flat with a mix of rocky and sandy profiles and are backed by high dunes or cliffs. Prevailing winds throughout most of the year are from the northwest, but major storms can bring large southerly swells. Visitor access to the survey beaches is limited. The waters around the islands, however, are used extensively by boaters and fishermen.

The Santa Barbara Channel is a major shipping route, and the channel and nearby Santa Maria Basin are major offshore oil production areas. The islands provide important wildlife breeding areas for sensitive species such as snowy plovers (*Charadrius alexandrinus*), which are federally listed as a threatened species.

Two beaches were sampled on November 20-23, 1992, and six beaches were sampled March 24 through April 11 and August 31 through September 5, 1993. The June (spring) surveys were not conducted to avoid disturbing nesting snowy plovers. Because Arlington Canyon beach is only 600 m long, data were extrapolated to a number/km basis. Beaches were surveyed by two to five persons per quarter.

Gulf of Mexico

Padre Island National Seashore

Padre Island National Seashore includes more than 112 km of Texas coast in the Gulf of Mexico (Figure 4). The island is bordered to the west by the hypersaline Laguna Madre, an estuary which separates the island from the Texas mainland. Beach survey sites are located along the Gulf-exposed shoreline in the northern section of the park. These beaches range in width from 25 m to 50 m and consist mostly of sand with varying amounts of shells. Converging currents that meet offshore near the middle of the island periodically result in a significant buildup of debris on nearby beaches. This area of the Gulf supports a large commercial and recreational fishing industry and notable offshore oil and gas production activities.

Because of excessive quantities of debris on the Padre Island beaches, sampling in 1990 through 1993 was conducted using different methods from those used at other parks (see **Methods**).

Six 50-m beaches were sampled on December 15-18, 1992, and on March 16-17, June 7-10, and September 7-23, 1993. Beaches were surveyed by four to seven persons.

Gulf Islands National Seashore

Gulf Islands National Seashore, the largest national seashore, encompasses 38,489 ha, of which 87% are submerged (Figure 5). The Seashore includes islands within the 240-km Gulf of Mexico coastline from West Ship Island, Mississippi, east to Santa Rosa Island, Florida. In the Florida District, one Gulf-facing survey beach is located on Santa Rosa Island, and another on Perdido Key. The three remaining survey beaches are on islands in Mississippi; two are exposed to the Gulf and the other to the Mississippi Sound. These three sites are accessible only by boat. Prevailing winds are generally from the south from March to August, and from the north from September to February. Eastern winds and currents transport sand from the eastern to the western islands. Erosion of the eastern ends of the islands and accretion on the western ends indicate significant occurrence of longshore drift.

Five 1-km beaches were sampled on December 23-30, 1992; four beaches on March 9-30, 1993; and five beaches on June 19-30 and September 8-14, 1993. Beaches were surveyed each quarter by two to ten persons.

Dry Tortugas National Park

Dry Tortugas National Park is located 110 km west of Key West, Florida, and sits astride the Florida Straits (Figure 6). Its 25,862 ha encompass a striking combination of historic resources and pristine subtropic marine environment. In addition to seven small waterless keys of beach-dune habitat (34 ha total) that constitute the Dry Tortugas, the park contains staghorn coral reefs, sand flats, and seagrass beds.

Due to the unique wind patterns that develop in the Gulf of Mexico and the location of the Dry Tortugas in the Florida Straits, the park experiences winter-prevailing winds from the northeast. These winds shift to the south during the summer. Winter winds tend to erode the smaller keys and alter the beach profile of East Key each year. When the winds shift in the summer, the smaller keys reappear above the tide line.

Dry Tortugas National Park can be reached only by boat or seaplane due to its remote location. This park is one of the least visited national parks, recording only 34,258 visits in 1992.

All beach survey sites are low slope and sandy substrate. No survey beach is 1-km in length because none of the island perimeters extend that length. East Key, windward, is 328 m in length, while East Key, leeward, is 300 m. The windward side of Loggerhead Key is 339 m, whereas the leeward side measures only 254 m in length. All debris accumulation rates were adjusted to number/km.

Beaches were sampled on December 12-20, 1992, and on March 5-15, June 5-19, and September 20-22, 1993. Surveys were conducted by one person.

Caribbean

Virgin Islands National Park

The U.S. Territory of the Virgin Islands is located south of the large islands of Cuba, Hispaniola (Haiti and the Dominican Republic), and Puerto Rico (Figure 7). The predominant year-round industries of the islands are tourism and fishing. The island of St. John is the smallest and least developed of the three largest U.S.-owned islands and is the site of the marine debris survey program. Approximately 57% of the island is federally owned. The 81-km shoreline curves tortuously around rocky points that jut out of the surf and lead into small bays with narrow sand and cobble beaches.

Two of the four survey beaches (Haulover Bay and Brown Bay) are on the northeast shore in areas that are the most inaccessible to the more than one million visitors each year. These sites are subject to debris from fishing and shipping interests from the nearby Anegada Passage. A third beach (Reef Bay) collects debris from the southeast, the direction of the predominant trade winds. The fourth site (Steven Cay) is on the west side of St. John, where the Caribbean meets the Atlantic. All survey beaches are low-gradient, influenced by moderate wave action and currents, and are less than one km in length. All debris accumulation rates were adjusted to number/km.

Beaches were sampled during December 30, 1992-January 3, 1993, and March 22-April 1, July 13-15, and September 21-27, 1993. Surveys were conducted by two to three people.

Southern Atlantic Coast

Canaveral National Seashore

Canaveral National Seashore is a 38-km section of coastal barrier located along the Atlantic coast of Florida (Figure 8). The park is bordered by the community of New Smyrna Beach to the north and the Kennedy Space Center to the south. The sand and crushed shell beach is relatively stable, wave energies are moderate, and the littoral current is weak. The beach, averaging 20 m in width, is bordered by intermittent dunes. Frequent beach overwash occurs. The survey beaches are spaced 0.4 km apart and are located at least 9 km from high-density visitor areas.

Five 1-km beaches were sampled on December 5, 1992, and on March 20, June 5, and September 18, 1993. Beaches were surveyed by twenty to twenty-five persons.

Cape Hatteras National Seashore

Cape Hatteras National Seashore encompasses 120 km of coastline that comprises a series of barrier islands in North Carolina (Figure 9). All survey beaches are sandy and low-gradient, exposed to the Atlantic Ocean, and influenced by moderate-energy waves and littoral currents. The Seashore's seaward location makes it particularly vulnerable to the effects of hurricanes and coastal storms. Swimming, fishing, and sunbathing are popular activities. Vehicular traffic is permitted on three survey beaches (Coquina Beach, Little Kinnakeet, and Ocracoke).

Five 1-km beaches were sampled January 7-19, April 8-19, June 14-18, and September 10-15, 1993. Beaches were surveyed by one to two persons.

Northern Atlantic Coast

Assateague Island National Seashore

Assateague Island National Seashore is a 60-km-long barrier island located in Maryland and Virginia (Figure 10). The island lies in the microtidal zone of the Mid-Atlantic coast; high energy waves have a greater influence on the island topography than the tides. Overwash and inlet formation/closure are the primary natural forces that sculpt the island's form. Geomorphological change is normally episodic and associated with storm events such as hurricanes and northeasters. Predominant littoral currents flow from north to south, resulting in net sand transport to the southern tip of the island. The northern portion of the island is experiencing accelerated landward migration and sand starvation resulting from the Ocean City Inlet jetty system (which has interrupted the normal littoral flow). The middle section of the island is relatively stable, while sand accretion is occurring on the southernmost portion.

In addition to topographic changes from storms and littoral drift, the beaches of Assateague Island experience an annual accretion-erosion cycle. A normal summer accretion of about 30 m in width and 2 m in height is typical, along with similar, counteracting winter erosion.

Initially, six 1-km beaches were included in the survey. Surveys were discontinued at Beach 3 in 1989-90 due to lack of available personnel. Two of the remaining five survey beaches are located in the northern portion of the Seashore. The central portion of the island also has two survey beaches; they are at least 50 m wide and are bordered by an intermittent primary dune line. Another survey beach is located on the island's rapidly accreting southern end in an area that supports an active recreational and commercial fishing industry.

Five beaches were surveyed on December 1-3, 1992, and on March 8-15, 1993; four beaches on June 2-7, 1993 (Beach 6 was not sampled due to nesting

Piping Plovers); and five beaches on September 9-10, 1993. Total item counts for Beach 2 for spring and summer were extrapolated from three 100-m transects actually sampled. Beaches were surveyed each quarter by two to six persons.

Cape Cod National Seashore

Cape Cod National Seashore encompasses 17,640 ha (63% in federal ownership) of outer Cape Cod, Massachusetts (Figure 11). The Seashore includes approximately 63 km and 24 km of undeveloped beaches on the Atlantic Ocean and Cape Cod Bay, respectively.

Time-averaged littoral drift patterns tend to move from the Atlantic Ocean north and west into Cape Cod Bay. Between October and April, prevailing winds are from the northeast to northwest, shifting to the southwest during summer. Northeast storms cause the greatest shoreline erosion.

Three of the five survey beaches are located on the Atlantic Ocean. These sandy, actively eroding, high-energy beaches are backed by 5-m to 7-m high dunes and a 25-m to 40-m high marine scarp. The remaining two survey beaches are located on Cape Cod Bay. These are sandy, low-energy beaches backed by low dunes, averaging 4 m in height.

Five 1-km beaches were surveyed on December 7-18, 1992, and March 16-25, 1993. Only one beach was surveyed on June 18, 1993, to avoid disturbance of nesting piping plovers. Four beaches were surveyed from September 27-30, 1993. Two to twenty persons conducted the beach surveys.

RESULTS

In order to facilitate comparisons between parks and years, data from Padre Island National Seashore, Virgin Islands National Park, and Dry Tortugas National Park are analyzed separately.

Fifth Year Report for Seven National Parks: 1992-1993

In 1992-93, a total of 115,065 debris items were found during 127 quarterly surveys of 36 beaches. Most debris items were plastic (95%) (Figure 12). Gulf Islands and Assateague Island had the lowest relative percentage of plastic to total debris (82% and 84%, respectively), whereas Olympic had the highest (98%). Olympic accumulated the most total debris per quarter (average: 2,028 items/km of beach), whereas Assateague Island accumulated the least (average: 175 items/km) (Figure 13). For all seven parks combined, even though total number of items found was greatest during winter (33,787 items: 965 items/km [n=35]), the accumulation rate of plastic debris was greatest during spring (27,477 items: 1,099 items/km [n=25]) and least during summer (19,199 items: 549 items/km [n=35]) (Figure 14).

The proportion of plastic by category (fishing, packaging, personal, and miscellaneous) varied seasonally (Figure 14). For example, the proportion of miscellaneous debris was greatest during spring, whereas summer was the period of greatest accumulation of packaging debris. Composition of plastic debris varied by park (Figure 15), with miscellaneous and packaging debris usually the most abundant items. Cape Cod had the highest percentage of fishing debris (30%), Assateague Island had the largest percentage of packaging debris (45%) and personal debris (18%), and Cape Hatteras had the greatest percentage of miscellaneous debris (85%).

Fishing gear constituted 9% (10,017 items) of all plastic debris for the seven parks. Of the total fishing debris, 44% was found at Cape Cod (4,396 items) and 28% at Olympic (2,758 items). Cape Cod accumulated over three times the national average of fishing debris (Table 1) and had 30% of its total plastic debris in the fishing debris category; Cape Hatteras had the lowest percentage of fishing debris (2% of total plastic) (Figure 15). Rope (of any length) comprised 48% of all fishing debris; Cape Cod had almost five times the national average for rope. Floats (all types) (15%) were the next most common fishing items. Olympic had nearly five times the number of pieces of monofilament line and gill-net floats as the national average. Cape Cod had approximately twice the number of open straps and five times the number of miscellaneous fishing materials as the national average (the majority of which were lobster bands).

Packaging items constituted 20% of all plastic debris (22,152 items at all seven parks combined) and varied between 8%-45% by park (Figure 15). Channel Islands had more than two times the national average of plastic bottles. The number of small bags at Cape Cod was greater than three times the national average. Channel Islands, Canaveral, and Cape Cod had more straws than the national average, and Canaveral had over four times the national average for foam packaging. Channel Islands, Cape Cod, and Canaveral had more than the national average of most packaging items (Table 1). Caps and lids, bottles, straws, small bags, and foam packaging made up 85% of the total packaging debris (25%, 20%, 17%, 16%, and 7%, respectively). Six-pack yokes comprised less than 1% of the packaging debris at all parks.

Personal items accounted for 5% of all plastic debris (5,212 items) (Figure 15). Only Assateague Island and Cape Cod had percentages of personal debris greater than 10% (18% and 14%, respectively). Channel Islands, Canaveral, and Cape Cod were the only parks with quarterly accumulation rates higher than the national average (Table 1). Balloons (36%) and tobacco accessories (18%) accounted for 54% of personal debris for all parks (Table 1). Cape Cod contained 73% of all tampon applicators (more than six times the national average) and had seven times the national average of cotton swabs. Cape Cod alone accounted for 50% of all balloons. Tobacco accessories were over two times the national average at Gulf Islands and Cape Cod. Channel Islands had more than three times the national average of toys.

Miscellaneous items dominated total plastic debris (71,804 items for all seven parks [66%]) (Figure 15). Three items (foam fragments [77%], hard fragments [13%], and small plastic sheets [6%]) comprised 96% of the miscellaneous category (Table 1). Olympic and Canaveral had much greater numbers of miscellaneous debris than the national average. At Olympic this was due to large amounts of foam fragments while at Canaveral high numbers could be traced to foam fragments, hard fragments, and small plastic sheets (<1m^2). All other parks had fewer miscellaneous items than the national average, especially Assateague Island (1/15th the average).

Medical debris comprised a very small percentage of total debris (145 items, 0.12%).

Entanglement debris comprised only 1% of all plastic debris (1,595 items), ranging from <1% at Cape Hatteras to 3% at Gulf Islands and Assateague Island (Table 2). Rope >1 m comprised 36% of all entanglement debris (577 items) and was the most common entanglement item at six of seven parks (5 items/km). Most entangling debris (920 items, 58%) was found at Olympic and Cape Cod (Table 2).

Ingestible plastic items were 41 times more abundant than entangling items (65,369 items) (Table 3). The proportion of ingestible to total plastics ranged from 32% at Cape Cod (311 items/km) to 87% at Cape Hatteras (355 items/km) (Table 3). Foam fragments made up 85% of all of ingestible items and were most abundant at Olympic (55% of all foam fragments).

The 10 most abundant debris items (Table 4) accounted for 81% of all plastic debris (93,230 of 115,065 items). Foam and hard fragments accounted for 49% of those items.

Glass was the most abundant non-plastic debris item (2,738 items, 2%) (Figure 12). Gulf Islands and Assateague Island each had higher percentages of glass than the national average (7%). Gulf Islands

(9%) and Assateague Island (6%) each had a greater percentage of metal debris than the national average (Table 1). Bottles comprised 60% of glass debris, most of which were found at Gulf Islands and Canaveral.

Padre Island National Seashore

In 1992-93 at Padre Island National Seashore, a total of 20,441 items was recorded for the six 50-m beach sections during all quarters. Of this debris, most was plastic (93%); of the plastic items, miscellaneous debris predominated (70%), composed primarily of hard and foam fragments (39% and 32%, respectively) (Figure 16). Packaging debris was the second most abundant plastic category (16%), followed by fishing (9%) and personal items (4%) (Table 1). The largest influx of marine debris occurred during winter (33%), followed by spring (29%), fall (17%), and summer (14%). The top 10 items (Figure 16), ranked by abundance, accounted for 86% of all marine debris items observed. Ingestible items were 20 times more common than entanglement items and were dominated by foam fragments (3,102 items/km, 48%) (Table 2 and Table 3). Three categories made up 94% of entanglement debris--gaskets (43%), rope >1 m (34%), and six-pack yokes (16%). Nonplastic debris was primarily glass (3%).

Virgin Islands National Park

Most debris items collected at Virgin Islands were plastic (84%) (Figure 17). Miscellaneous plastics items were the most numerous (42%), followed by packaging (34%), fishing debris (20%), and personal items (4%) (Table 1). Miscellaneous plastics were dominated by hard fragments (73%). The top ten plastic items were hard fragments, rope <1 meter, straws, caps & lids, foam fragments, rope >1 m, sheets <1 m^2, bags <1m^2, bottles <1 gallon, and food containers. Ingestible items (primarily foam fragments) were twice as abundant as entangling items (Table 2 and Table 3). Rope and gaskets were the most common entangling items. Fall was the season of greatest debris accumulation (36%), followed by winter (24%), summer (21%), and spring (19%).

Dry Tortugas National Park

Plastic items accounted for 71% of all debris collected, followed by glass and metal (14% each) (Figure 18). Of the plastic debris, miscellaneous items accounted for over half (54%), followed by packaging (22%), fishing (19%), and personal items (4%) (Table 1). Foam fragments comprised the majority of plastic debris, followed by hard fragments, crustacean pot floats, bottles <1 gallon, foam cups, rope <1 meter, caps and lids, sheets <1 m^2, foam food containers, and bags <1 m^2. Ingestible plastic items were 14 times more abundant than entangling items (Table 2 and Table 3). Spring was the season of greatest accumulation (29%), followed by summer (26%), winter (23%), and fall (21%).

Summary of Results - Five-Year Program (1988-1993) at Seven National Parks:

Plastics comprised the majority of debris found at all seven parks over the five years of surveys. Nationally, plastics continued to comprise about 90% of the total debris ranging between 86% and 91% (Figure 19). The average quarterly accumulation rate for plastic debris increased by 21% between 1988-89 and 1992-93 (711 to 860 items/km). Olympic showed the largest increase (537 to 1990 items/km, not including non-comparable data from the first year). Assateague Island showed the largest percentage decline in average accumulation rate (780 to 145 items/km, -81%) over the five year span (Figure 20). Gulf Islands (-29%) and Cape Cod (-20%) also showed evidence of declining amounts of debris. Channel Islands demonstrated declining debris for the last three years, even though accumulation rates were higher in the fifth than the first year.

The average accumulation of total debris (plastic and nonplastic) varied by quarter and by year for all seven parks (Figure 21). Seasonal patterns were evident only at Channel Islands where the most debris was consistently reported in winter. Debris accumulation at Olympic increased in all years.

Accumulation rates at Channel Islands and Assateague declined for three consecutive years. All other parks showed both increases and decreases in accumulation rates between years over the 5-year period. Nationally, mean quarterly accumulation rates for all debris increased, from 820 to 906 items/km between 1988 and 1993. Nationally, the average quarterly accumulation rates (for all debris) remained steady (about 900 items/km) over the last three years.

Considerable variation in quarterly accumulation rates of debris existed within parks (Figure 22). Most parks exhibited a wide range of accumulation within and between beaches. Channel Islands, for example, showed about a six-fold level of variability between Beaches 3 and 4, although both beaches were only a few kilometers apart.

Composition of plastic debris fell primarily within the miscellaneous (53%) and packaging (28%) categories (Figure 23). Of those items classified as miscellaneous plastic, most were either foam or hard fragments (64% and 22%, respectively). Caps and lids, bottles, small plastic bags, and straws comprised 77% of the total packaging debris. Fishing debris constituted only 12% and personal items only 7% of total plastic debris. Fishing debris and personal debris declined 17% and 28%, respectively from 1988-1993. Packaging debris declined substantially through the five years (-34%) whereas miscellaneous debris increased by 52% (Figure 24). The overall slight increase in plastic debris, therefore, is directly traceable to an increase in foam and hard fragments.

Figure 24 displays the composition of plastic debris by showing fishing, packaging, personal, and miscellaneous plastics by park and year. A substantial change in composition between years for some parks is evident. Olympic had a much greater percentage of plastic debris in the miscellaneous category in the fifth year than shown for the first year; this is due in part to the fact that fragments were not counted in the first year.

Gulf Islands had a slight, but continual, increase in miscellaneous plastics, whereas Canaveral showed just the opposite trend for four of the five years. For all parks combined, miscellaneous plastic debris is shown to be an increasing percentage of the total debris load through the five years.

Depending upon the year, 13 different items comprised the ten most abundant debris items (Table 5). Although rankings varied by year, foam and hard fragments were first or second in abundance in all years; five of the seven parks had foam fragments as the most abundant debris item (Figure 25).

Entanglement items declined over the last three years of the surveys while the rate of increase in ingestible items slowed. Medical debris declined for the last three years (Figure 26); however, these change should be viewed with caution as they reflect changes in very low numbers. Sewage-related debris declined, primarily due to a decline in tampon applicators found at Cape Cod.

Comparison of 5-Year Data With and Without Fragments

Clearly, foam and hard fragments comprised a large proportion of the debris during the five years of surveys. Removal of fragments from the analysis, however, still places plastics as the predominant debris item (Figure 27). Composition of the plastic debris is significantly influenced by the inclusion or exclusion of fragments in the analysis (Figure 27). When fragment are included, the miscellaneous items category is the dominant source. By excluding fragments, miscellaneous items are third in abundance behind packaging and fishing items. Plastic fragments, as a percentage of total plastic debris, varied considerably among parks (Figure 28). Olympic had the highest percentage of fragments (66%), whereas Cape Cod had the lowest (21%). Plastic remains the predominant debris type, however, even with removal of fragments from the analysis.

Analysis of ingestible items is also significantly influenced by the exclusion of fragments (Figure 29). The ratio of ingestible to entangling items drops from 22 to 6 when fragments are excluded. Yearly accumulation rates also change upon removing fragments from the analysis (Figure 30), and Cape Cod clearly becomes the park with the highest marine debris accumulation rates.

DISCUSSION

Fifth Year Report for Seven National Parks: 1992-93

Plastic items continued to be the primary debris item found on park survey beaches through the fifth year of sampling. More than 90% of all debris on most park beaches was plastic. The preponderance of plastic items at park survey beaches contrasts with much lower values at other survey sites in the U.S. (63%) reported by the Center for Marine Conservation (Hodge et al. 1992). Divergent methodologies may account for much of the differences between the Center for Marine Conservation and National Park Service studies. The National Park Service conducted its survey during each season whereas the Center for Marine Conservation's surveys were conducted as part of annual beach clean-ups. Also, the Center's surveys were for the most part conducted on beaches in urban areas and other areas receiving considerable debris from local sources. The National Park Service survey beaches were for the most part considerably more remote. The Center for Marine Conservation also sampled areas of beaches, such as within or behind dunes, that were not surveyed by the National Park Service. Differences in definitions of certain debris items may also account for differences in overall results. For example, the National Park Service refers to rubber items as plastic, whereas the Center for Marine Conservation keeps them in a separate category. Finally, the Center for Marine Conservation uses different groups of volunteers each year, whereas the National Park Service surveys had been conducted by many of the same personnel.

Of the seven parks consistently sampled during the past five years, Olympic National Park had the largest debris deposition in 1992-93 and Assateague National Seashore had the least. Although Assateague and Cape Hatteras National Seashores are not the most isolated parks, coastal dynamics may reduce the amount of debris accumulation.

The 1992-93 surveys confirmed earlier observations that debris accumulation is a continuous process (Manski et al. 1991, Cole et al. 1992, Cole et al. 1995). Substantial, though variable, quantities of debris typically accumulated on cleared beaches in succeeding surveys (Figure 21). A study of marked debris at Padre Island National Seashore recorded little lateral movement of debris into cleared study beaches from adjacent areas (Miller 1993). These results were consistent with findings of similar studies in Alaska (Johnson and Merrell 1988) and the Mid-Atlantic region (Center for Marine Conservation 1990) in which little lateral movement of debris was observed. Debris found on survey beaches, therefore, presumably reflected "new" marine accumulation of a suspended offshore load, although uncovering of debris buried in the beach by wind or wave action may contribute to the recorded debris in some surveys (Johnson 1989, Miller 1993).

Miscellaneous plastic dominated the types of debris observed on park beaches. Most of the miscellaneous plastic debris (90%) was foam and hard fragments. Some of these fragments clearly came from degradation of items that would have originally been classified in other categories (e.g., breakdown of foam used for insulation or flotation). The only criterion applied in determining whether an item was a fragment is that the item be less than one-half of its original size.

For the seven parks, identifying sources (e.g., fishering activities, oil platforms) of marine debris continued to be difficult because much of what washed ashore had no distinguishing or unique identifying characteristics. For example, packaging such as plastic bags and bottles could have easily originated from either fishing vessels as galley waste or from beach users. Considerable fishing activity occurred in the vicinity of all the survey beaches, yet only 9% of plastic debris was clearly attributable to that source. With that in mind, our analysis probably underestimated the contribution of fishing-related debris.

Some items, however, were clearly attributable to a source. For example, hagfish traps were unique (in this study) to the hagfishing industry of California. Cruise ship debris occasionally had identifiable logos and therefore was traceable. The Environmental Protection Agency considers tampon applicators and cotton swabs to be indicative of sewage-related debris (David Redford, EPA, pers. comm.).

Several examples of international shipping-related debris were found in 1992-93. Olympic National Park again noted many objects of Japanese origin, believed to come from ships entering Puget Sound. Other sources of debris found in survey parks in 1992-93 include France, Germany, Mexico, Philippines, and Singapore.

Padre Island National Seashore, Virgin Islands National Park, and Dry Tortugas National Park

Padre Island National Seashore continued to accumulate far more marine debris than any other park surveyed. Converging currents from the Gulf of Mexico make Padre Island an inevitable target for debris. A considerable amount of debris suspected to be related to the shrimping industry (e.g., rubber gloves and salt bags) was found in the same time period as the shrimpers were working near shore (John Miller, Padre Island National Seashore, pers. comm.). This evidence was considered sufficient to target the shrimping fleet for further investigation.

When all ten parks are considered, Virgin Islands had the second highest debris accumulation rate next to Padre Island. Straws were found in abundance relative to mainland survey sites. These may have been products of the cruise ship and charter boat industries. Logos on debris materials were also useful in identifying cruise line debris. A complicating factor in the Virgin Islands was the tendency for residents to spontaneously clean beaches.

The commercial and recreational fisheries surrounding the Dry Tortugas were likely a major source of debris on the islands. Shipping channels to the north and south of the Dry Tortugas are additional sources of debris.

Summary of Results of the Five Year Program at Seven National Parks: 1988-1993

Although continued and substantial variability in the five years of data precludes detailed statistical analyses, some general observations can be made.

Complex Accumulation Processes

Debris accumulation varied considerably between years for all parks (Figure 21). A seasonal pattern, however, was discernable for Channel Islands, where most debris accumulated during the winter, and for Cape Cod, where most debris accumulated in the spring. The higher amounts of debris at Channel Islands may be the result of increased fragmentation during winter storms and coastal dynamics. Lack of information from Channel Islands for spring (due to nesting birds) made the analysis incomplete. At Cape Cod, a lack of spring sampling on many beaches (due to the presence of nesting Piping Plovers) led to an anomaly in data collection; the remaining beaches were those with the greatest amounts of debris, thus skewing spring results higher than might otherwise be expected.

It is not clear why some beaches exhibit a high variability in accumulation rates of debris. (Figure 22). Examples from Olympic, Channel Islands, Cape Hatteras, and Cape Cod indicate that variability is related to converging or passing currents, funneling winds, and eroding beaches. These forces vary in direction and intensity and likely affect the variability in debris accumulation between years at any particular site. Storm effects are probably the cause of much of the variability. Beaches at Assateague, for example, are occasionally swept clean by storm overwash (Jack Kumer, Assateague Island National Seashore, pers. comm.).

For the period 1988-1991, Cape Cod had the greatest overall accumulation rate of debris (excluding Padre Island, Virgin Islands, and Dry Tortugas). Cape Cod's totals were surpassed by Olympic in 1991-92 and 1992-93. The average accumulation rates at Cape Cod remained similar during the period of 1988-1991, reflecting either a constant accumulation process, a more consistent sampling regime, or both. Olympic had the least accumulation of debris for two of the five years, possibly due to inconsistencies in collecting fragments during the period. Given that possibility, Cape Hatteras and Assateague probably represent the lowest debris accumulation rate. No consistent patterns were seen for overall changes between years for all parks (Figure 20). Only Olympic registered increased debris accumulation each year. Debris accumulation has generally declined at Channel Islands and Assateague over the past three years. The remainder of the parks have shown increases and decreases, although the national averages have increased slightly each year.

Debris accumulation appears to be a stochastic process driven by storms, human activities, and other unpredictable events. Some of the variability in the data comes from single, large-scale accumulation events. Channel Islands, Olympic, and Cape Cod, for instance, each received a large number of foam fragments on one beach during one survey. Characterizing this variability will take time before statistically valid trend assessments and accumulation rate predictions are possible. Nevertheless, the data exhibits no indication that overall accumulation of debris is abating.

Debris Profile

Although variation in debris accumulation rates exists between years, substantial variation in the composition of debris does not appear. Miscellaneous and packaging debris comprise the two predominant categories of plastics for all years, although miscellaneous items appear to be an increasing percentage of total debris. This increase may be due to an increased emphasis on fragments over the past three years.

Most of the more common debris items remained on the top ten list during 1988-1993, although the rank of some items changed. The predominance of foam and hard fragments as a percentage of the total debris load was especially consistent. Several other items (such as caps and lids and bottles <1 gallon) were also dependable indicators of debris accumulation.

Entanglement and Ingestion

Entanglement debris has remained a very low percentage of the total debris, although absolute accumulation rates have not been trivial (1-33 items/km/quarter in 1992-93, excluding Padre Island National Seashore, Virgin Islands National Park, and Dry Tortugas National Park). Nationally, entanglement debris declined in each of the past three years (Figure 26). This low percentage of entanglement debris is an important finding in light of known effects on marine wildlife (Cottingham 1988).

Considerable changes were noted in the accumulation of ingestible plastics for all four years (Figure 26). Olympic's large increase between 1989-90 and 1990-91 was likely due to an increased emphasis on surveying for fragments. Increased ingestible items for Channel Islands during the same period was the result of a single, large accumulation on one beach. The large decline in ingestible items found at Assateague after 1990-91 resulted from a change in survey techniques; very small fragments were no longer included in the survey (Turner and Kumer 1994).

Medical and Sewage Debris

Although large percentage changes between years occurred for medical debris (Figure 26), this percentage change was due to changes in low numbers. An increase of one, for example, could have translated to an increase of 100% in a particular park. It is useful to note that accumulation rates for medical debris declined for three consecutive years.

This same analysis should be considered when interpreting sewage-related items. Cape Cod, however, did record a large increase in total tampon applicators in 1990-91 from the previous year (from 515/km to 1085/km). These items then declined in abundance to 589/km in 1991-92 and to 20/km in 1992-93.

Comparison With and Without Fragments

Analysis of the cumulative five year data with and without foam and hard fragments reveals the large impact these two items have on the overall debris load. The analysis raises the question as to whether or not foam and hard fragments should be included in future long-term monitoring plans.

Several parks showed large percentages of their total debris load as fragments, particularly foam fragments. The number of foam fragments can only get larger as foam pieces continue to break down. Foam also moves very easily on and off beaches making accurate counts nearly impossible. Accuracy is also compromised when large amounts of fragments are on the beach and estimation is the only logical survey alternative.

Fragments, however, are an important item when considering the effects of marine debris on fish and wildlife because fragments are readily ingested by a variety of animals. The ubiquity of fragments in the environment and their potential impact on wildlife provide a strong argument for their inclusion in future surveys.

To resolve some of the issues surrounding the survey of fragments, an alternative survey method could be considered. A sub-sampling of fragments could be conducted on selected beaches where fragments are known to be a problem (e.g., Olympic National Park). These smaller surveys, in conjunction with increased studies on the impact of fragments on marine wildlife, could help to develop a better understanding of the dynamics and effect of fragments in the marine coastal environment.

Quality Control

Methodological variation at several parks led to some inconsistencies in the data sets during the five year program. For example, Canaveral National Seashore showed a decline in plastics as a percentage of total debris from 1989-90 to 1990-91. This trend may not be real, however, because certain debris categories were not surveyed in both years. Additionally, Olympic National Park did not sample nonplastics for the first year, skewing the results from that park. Most parks, however, consistently followed standard sampling procedures and internal results were comparable.

Factors Influencing Debris.

Factors influencing the types, distribution, and abundance of debris found on the beaches were discussed in the 1990 report (Manski et al. 1991). These factors include proximity to commercial fishing and shell-fishing areas, ports and shipping lanes, military installations, and urban centers, as well as natural influences such as coastal storms, beach orientation with respect to prevailing winds, offshore currents, and intensity of sunlight.

Highlights of National Park Marine Debris Monitoring Program

The five-year National Park Marine Debris Monitoring Program was the first large-scale effort in the United States aimed at identifying and categorizing marine debris. Major accomplishments of the program include the following:

1. Identification of indicator items. Over the five-year program, quarterly surveys of many items proved to be taxing to both personnel and budgets. By measuring many debris items, a few indicator items were identified which can serve as indices to the entire debris load (e.g., plastic bottles <1 gallon). This will enable surveys to be conducted with considerably less effort. Reduced effort is a critical consideration when planning long-term marine debris surveys.

2. Determination of survey frequency. Quarterly surveys most probably underestimate the total numbers of debris items. It appears, however, that quarterly surveys are useful in determining trends in accumulation rates. Daily surveys may be the best method to accurately determine total numbers of items, although this survey frequency is very time- consuming and expensive.

3. Use of volunteers. Many of the parks would not have been able to conduct their surveys without employing the use of volunteers. Volunteer use, however, was not without its problems. Some volunteers had difficulty identifying debris items. Additionally, many volunteer crews did not remain constant and new crews required training each survey period. To resolve these problems, many parks had volunteers collect the debris into bags and the debris was then sorted later by more experienced personnel. In some parks, volunteer efforts declined over the five-year period due to the tedium and difficulty of collecting debris.

4. Public awareness and education. Several parks developed interpretative programs on marine debris as a result of their participation in the five-year monitoring program. Gulf Islands National Seashore was especially active in using the survey results to heighten public awareness of marine debris issues.

5. Interagency cooperation. The monitoring program would not have been possible without a high degree of cooperation between federal agencies (National Park Service, National Marine Fisheries Service, and U.S. Environmental Protection Agency) and the nonprofit sector (Center for Marine Conservation). Each served to provide resources and guidance and maintained a high degree of information exchange in order to facilitate the monitoring program.

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FIGURES

Figure 26. Change in mean accumulation rates for selected debris categories between 1988-89-1989-90, 1989-90-1990-91, 1990-91-1991-92, and 1991-92-1992-93.

Figure 27. Comparison of the composition of total debris and plastic debris with and without the influence of foam and hard fragments in 1988-93.

Figure 28. Percentage of composition of plastic debris composed of foam and hard fragments at seven parks in 1988-93.

Figure 29. Differential accumulation rates of ingestible debris with and without the influence of foam and hard fragments in 1988-93.

Figure 30. Total yearly plastic accumulation rates by park without the influence of foam and hard fragments in 1988-93.

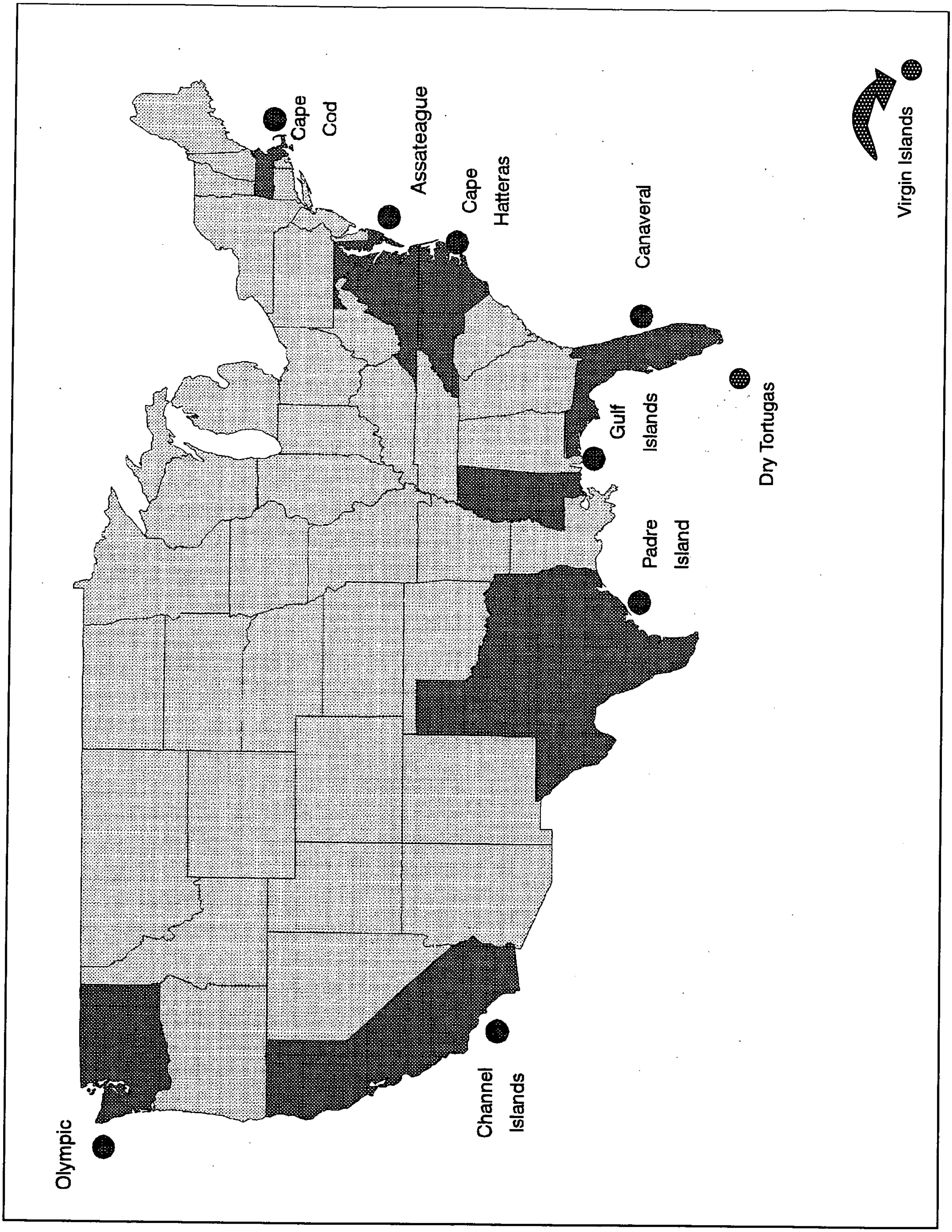

Figure 1. Location of 10 national park units participating in the National Park Marine Debris Monitoring Program, 1988-1993.

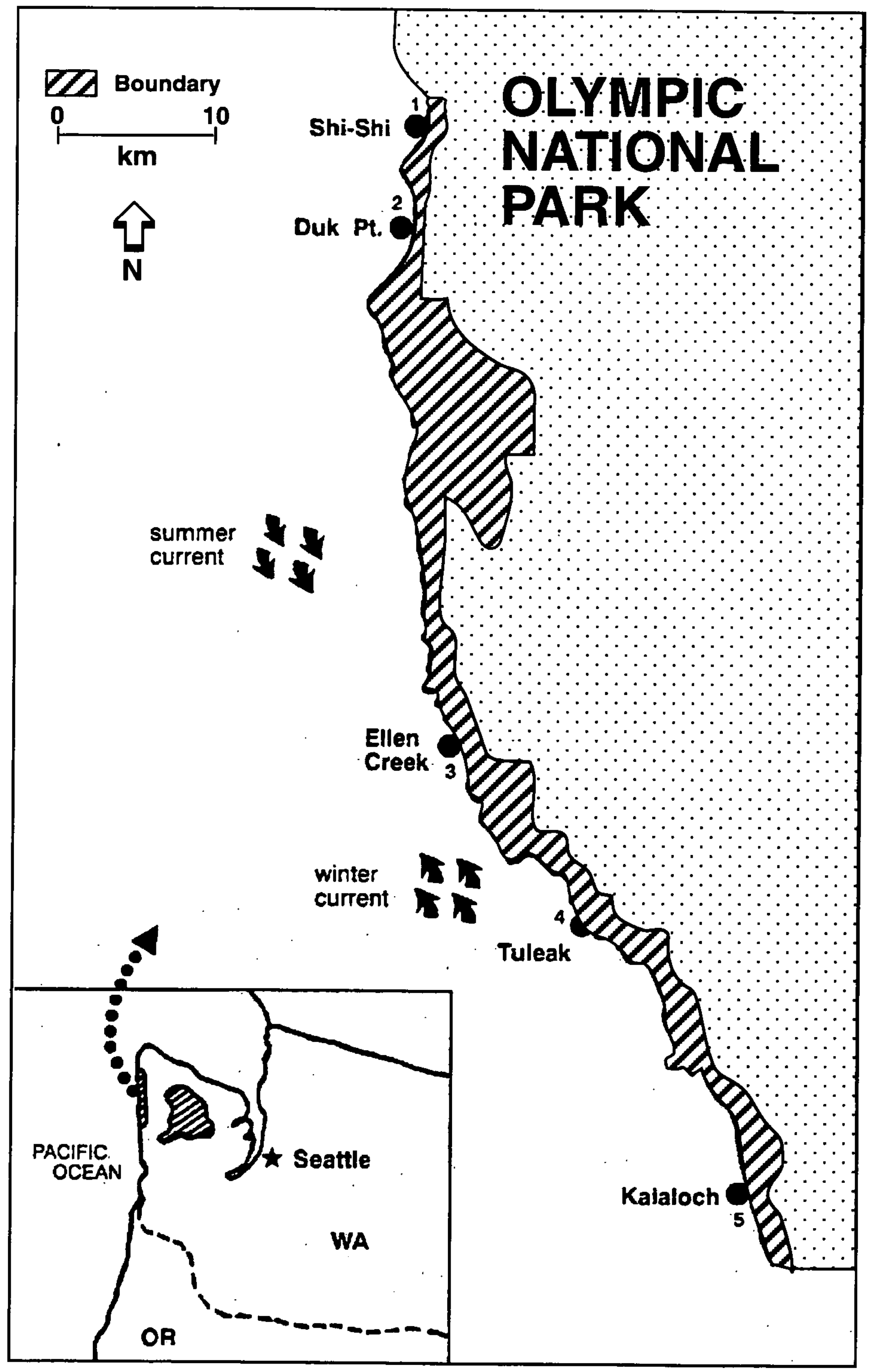

Figure 2. Olympic National Park and marine debris survey sites. Survey beaches are labeled and numbered 1-5.

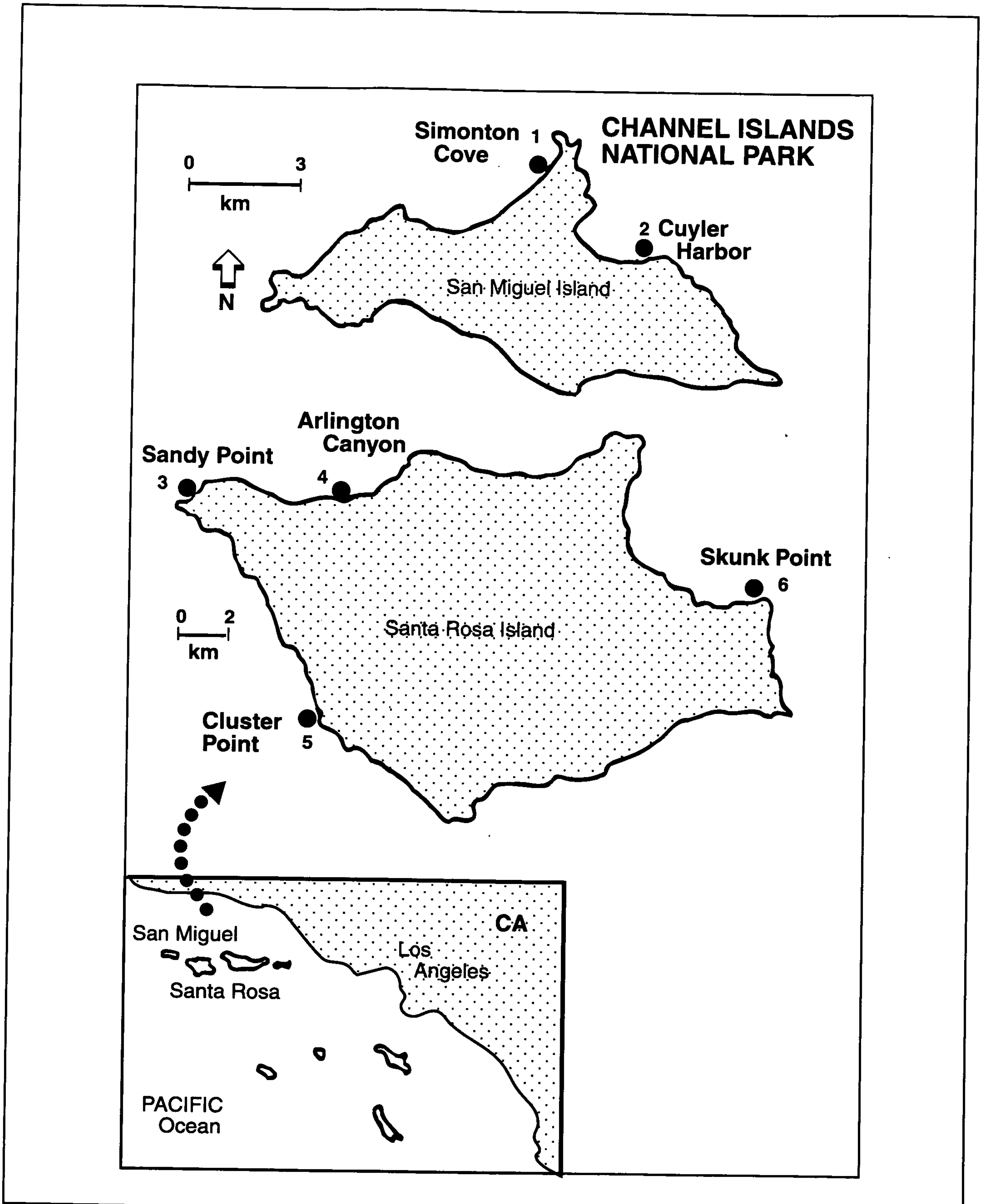

Figure 3. Channel Islands National Park and marine debris survey sites. Survey beaches are labeled and numbered 1-6.

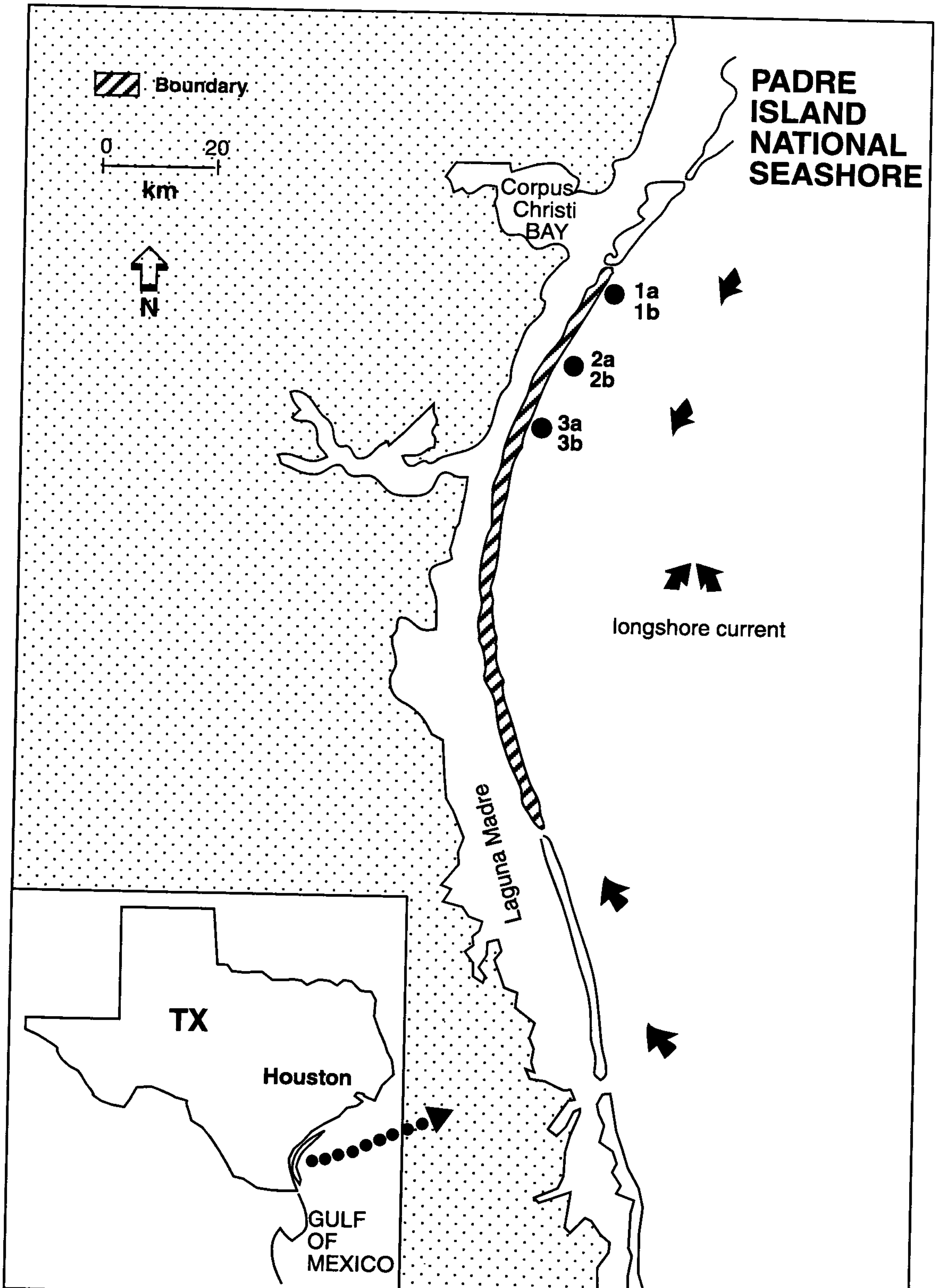

Figure 4. Padre Island National Seashore and marine debris survey sites. Survey beaches are labeled and numbered 1-3 (a,b).

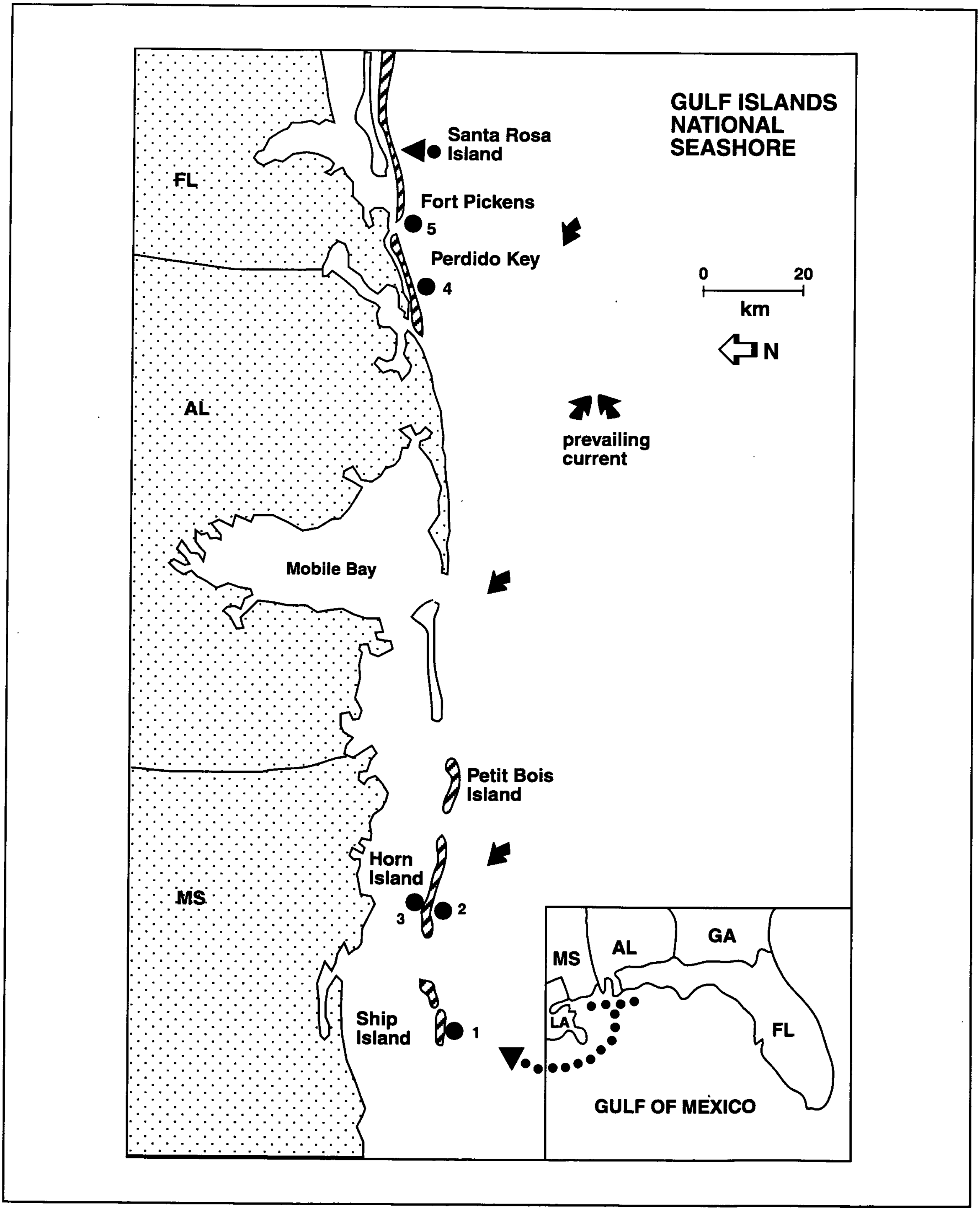

Figure 5. Gulf Islands National Seashore and marine debris survey sites. Survey beaches are labeled and numbered 1-5.

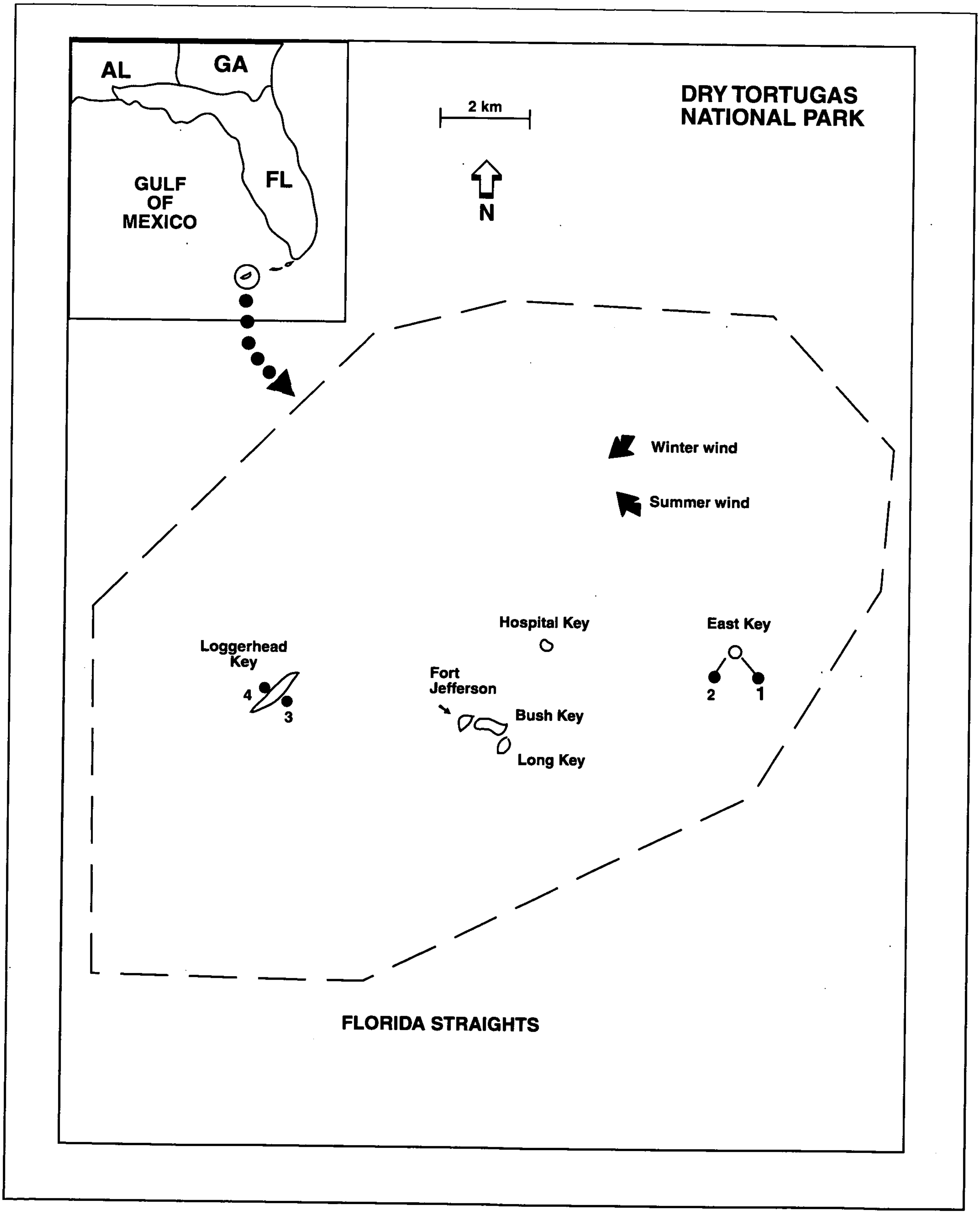

Figure 6. Dry Tortugas National Park and marine debris survey sites. Survey beaches are labeled and numbered 1-4.

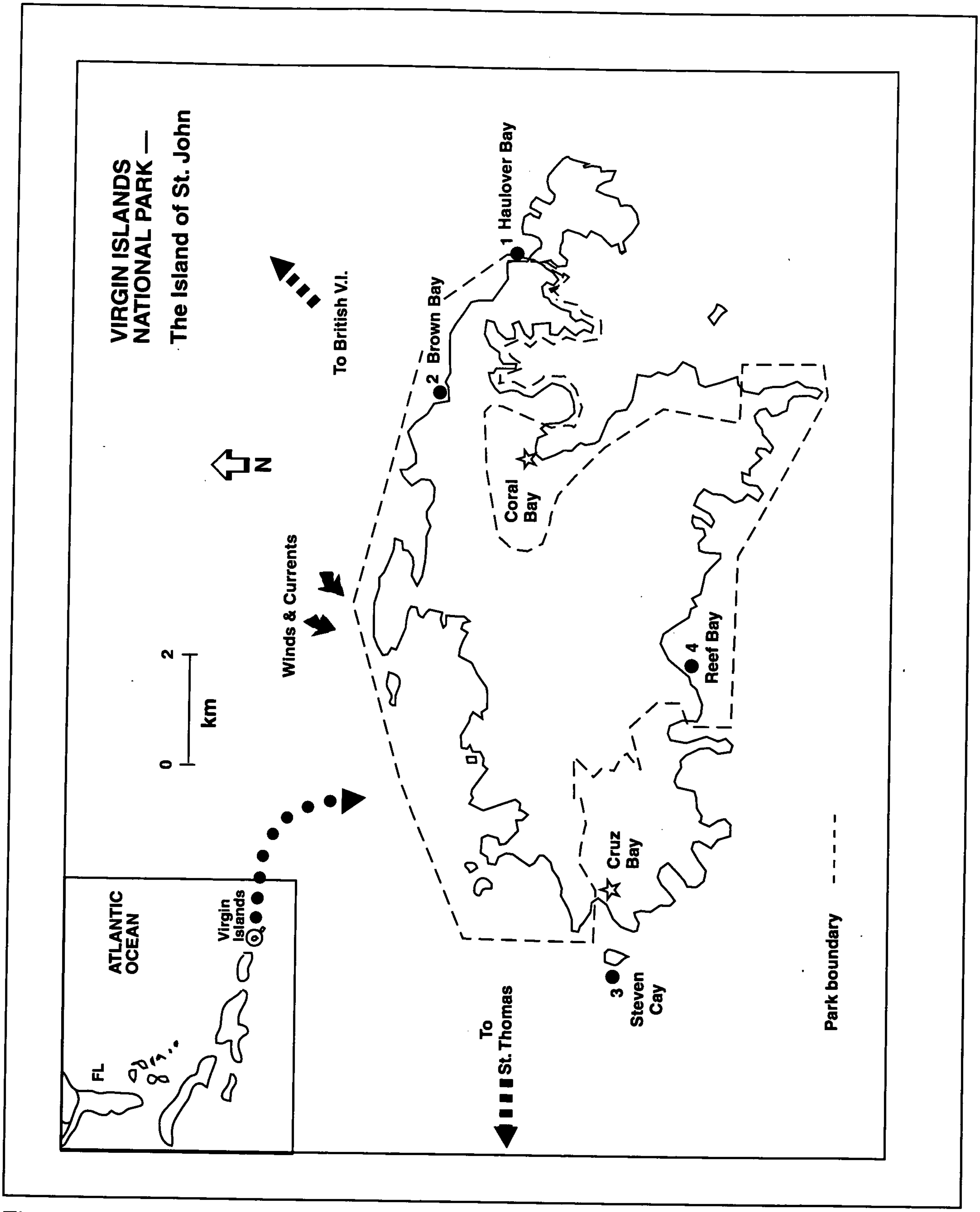

Figure 7. Virgin Islands National Park and marine debris survey sites. Survey beaches are labeled and numbered 1-4.

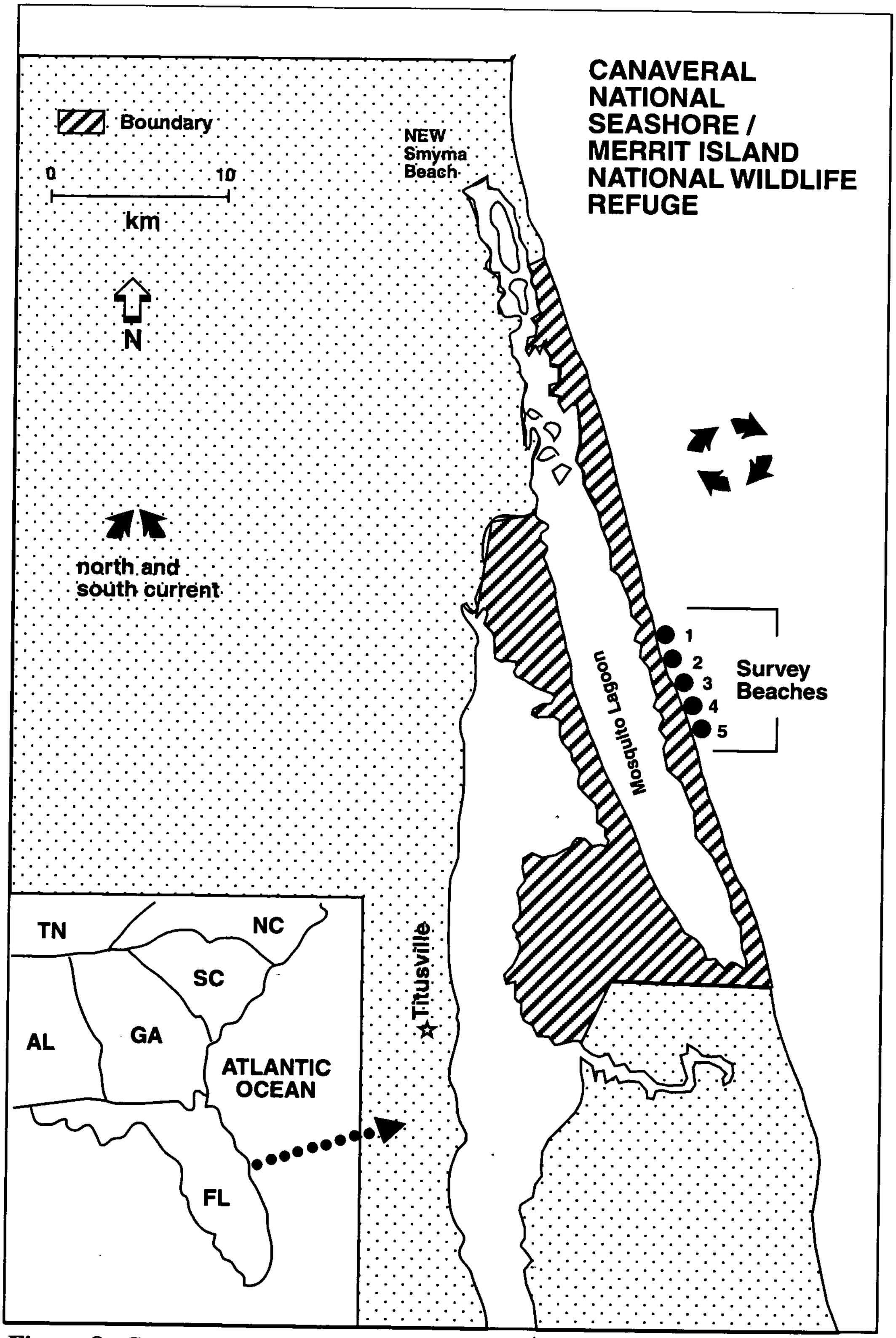

Figure 8. Canaveral National Seashore and marine debris survey sites. Survey beaches are labeled and numbered 1-5.

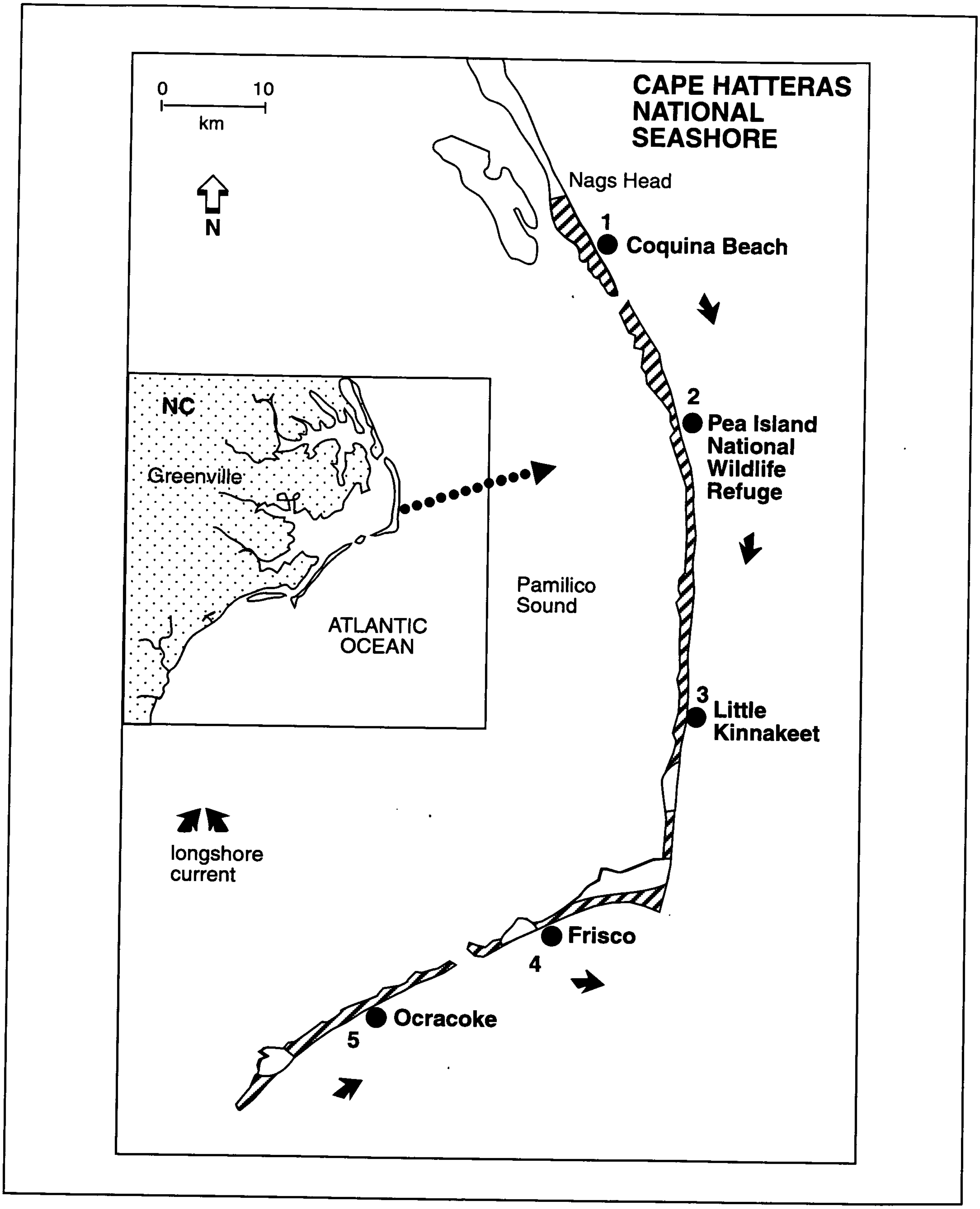

Figure 9. Cape Hatteras National Seashore and marine debris survey sites. Survey beaches are labeled and numbered 1-5.

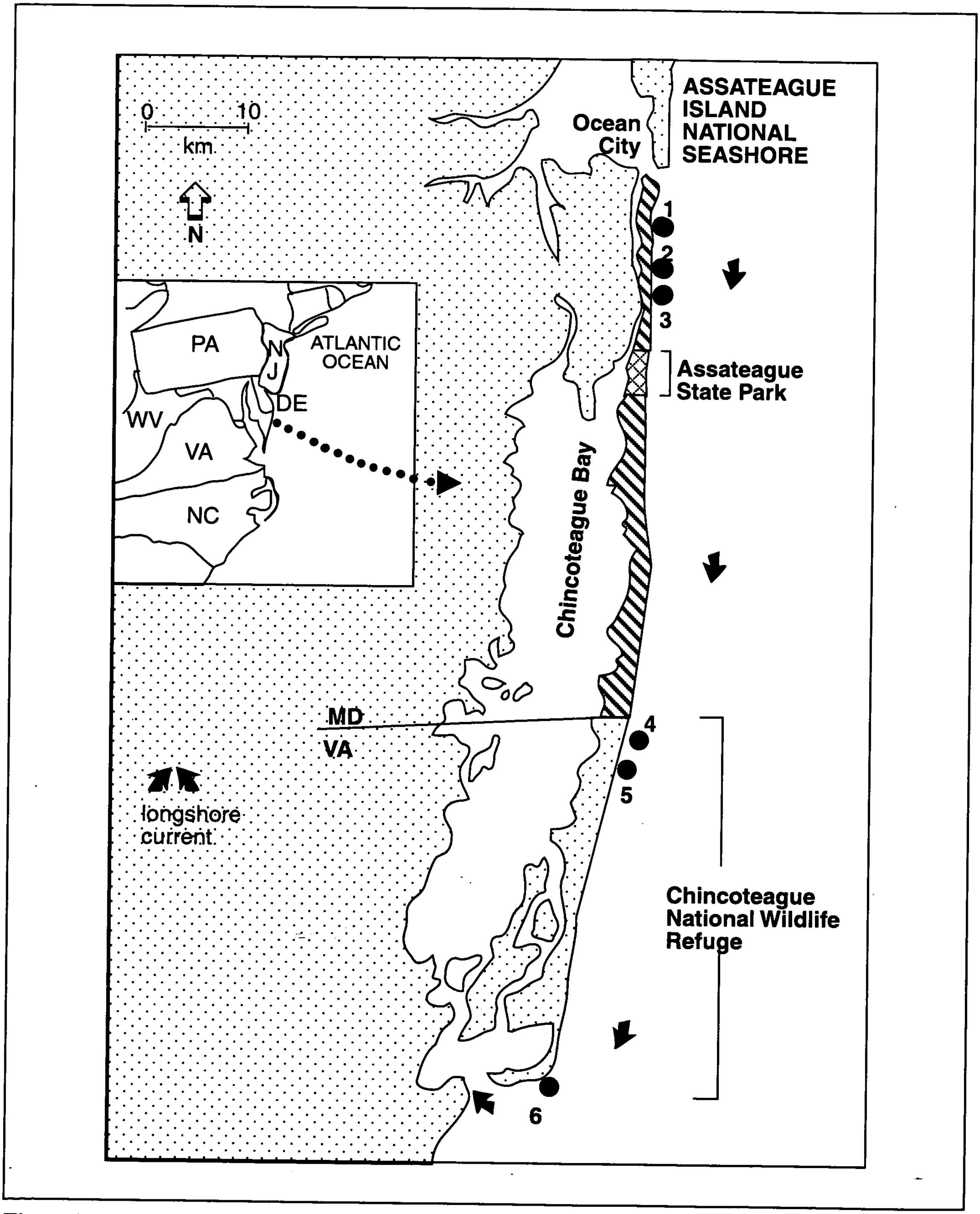

Figure 10. Assateague Island National Seashore and Marine debris survey sites. Survey beaches are labeled and numbered 1-6 (beach 3 is no longer surveyed).

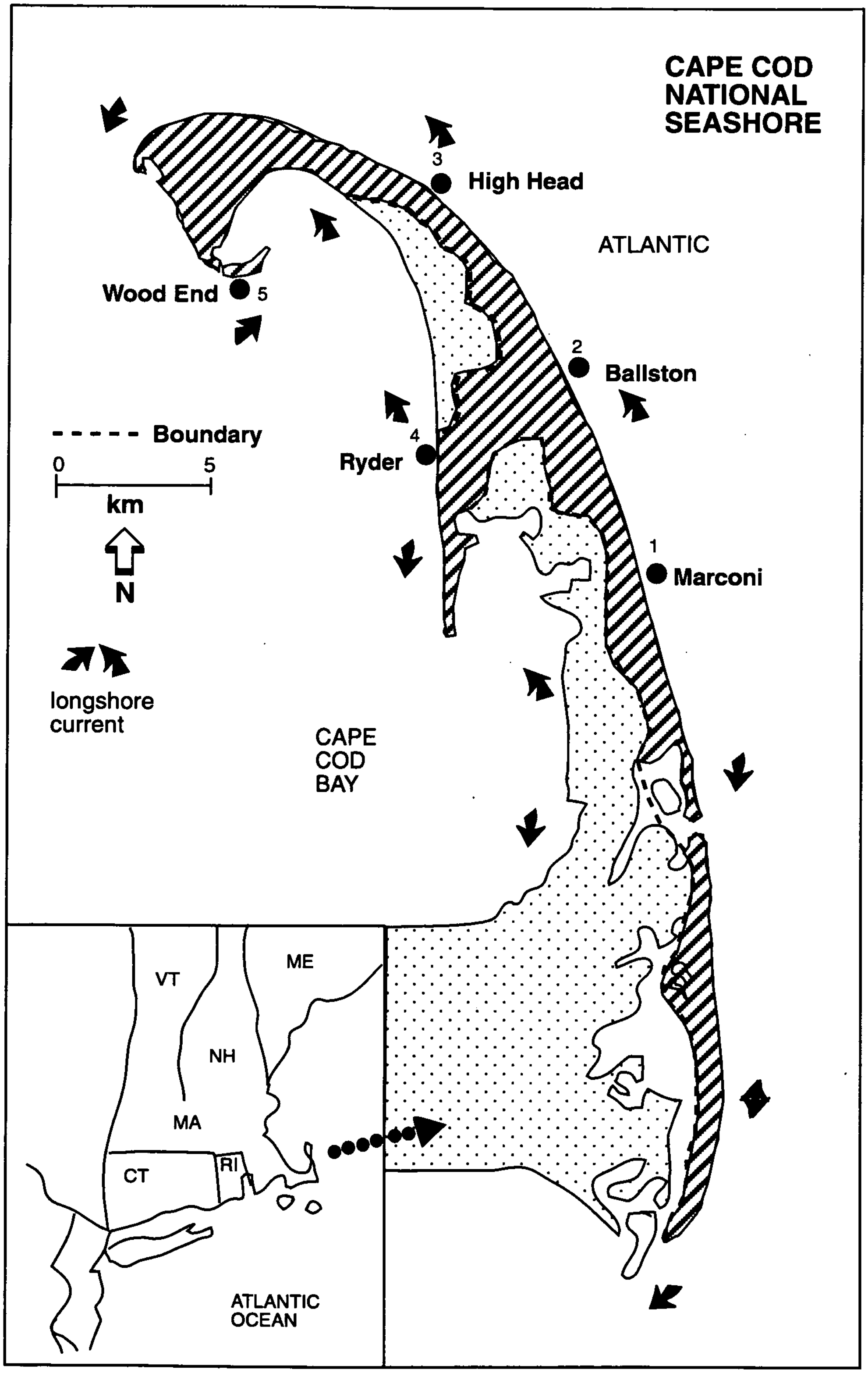

Figure 11. Cape Cod National Seashore and marine debris survey sites. Survey beaches are labeled and numbered 1-5.

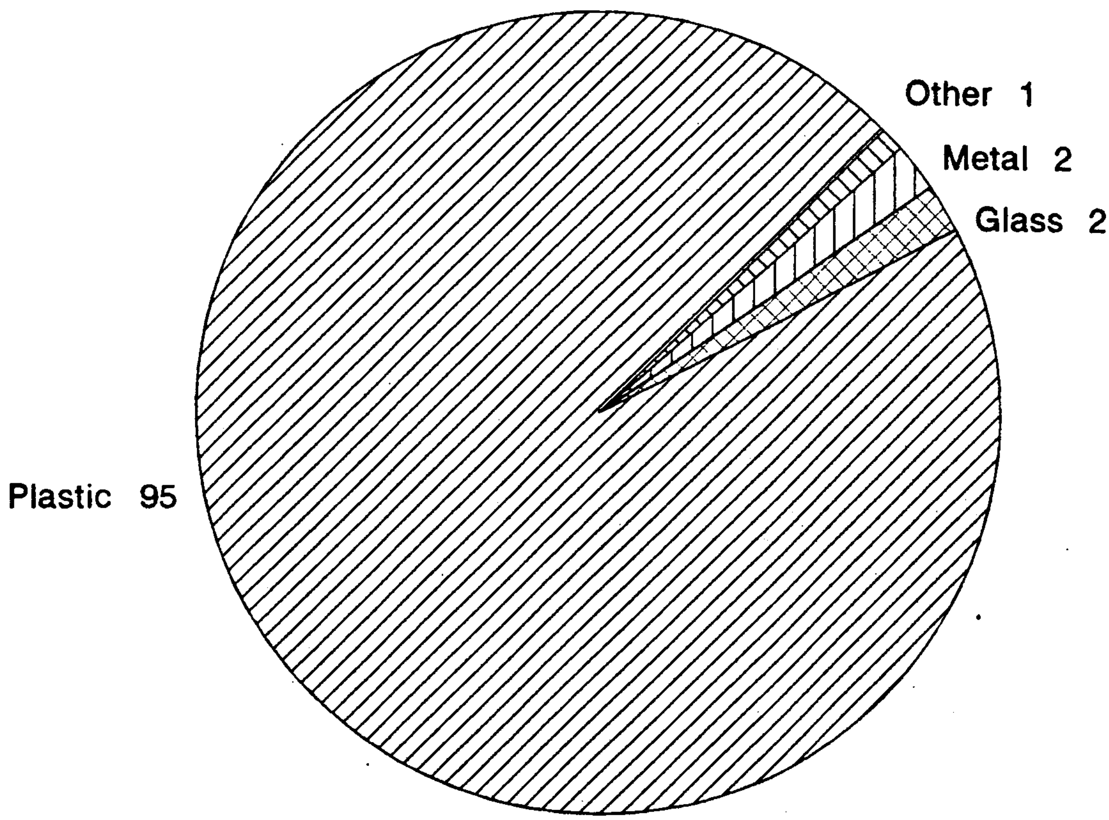

Figure 12. Percentage composition of human-generated debris at seven national parks in 1992-93. "Other" includes paper, cloth, and leather.

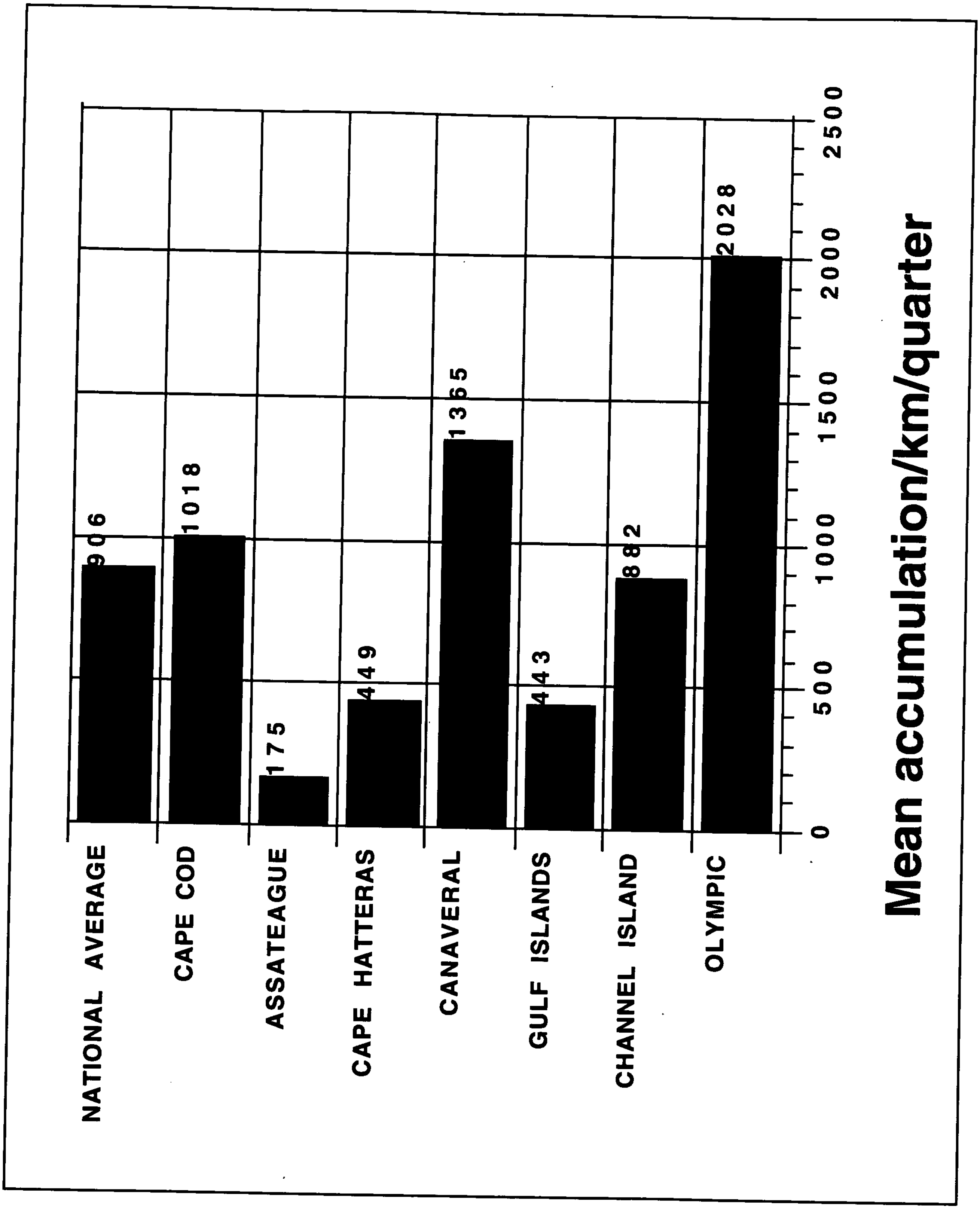

Figure 13. Mean quarterly accumulation rate of marine debris (plastic and nonplastic) at seven national parks in 1992-93. National average is the average accumulation rate of all seven parks combined.

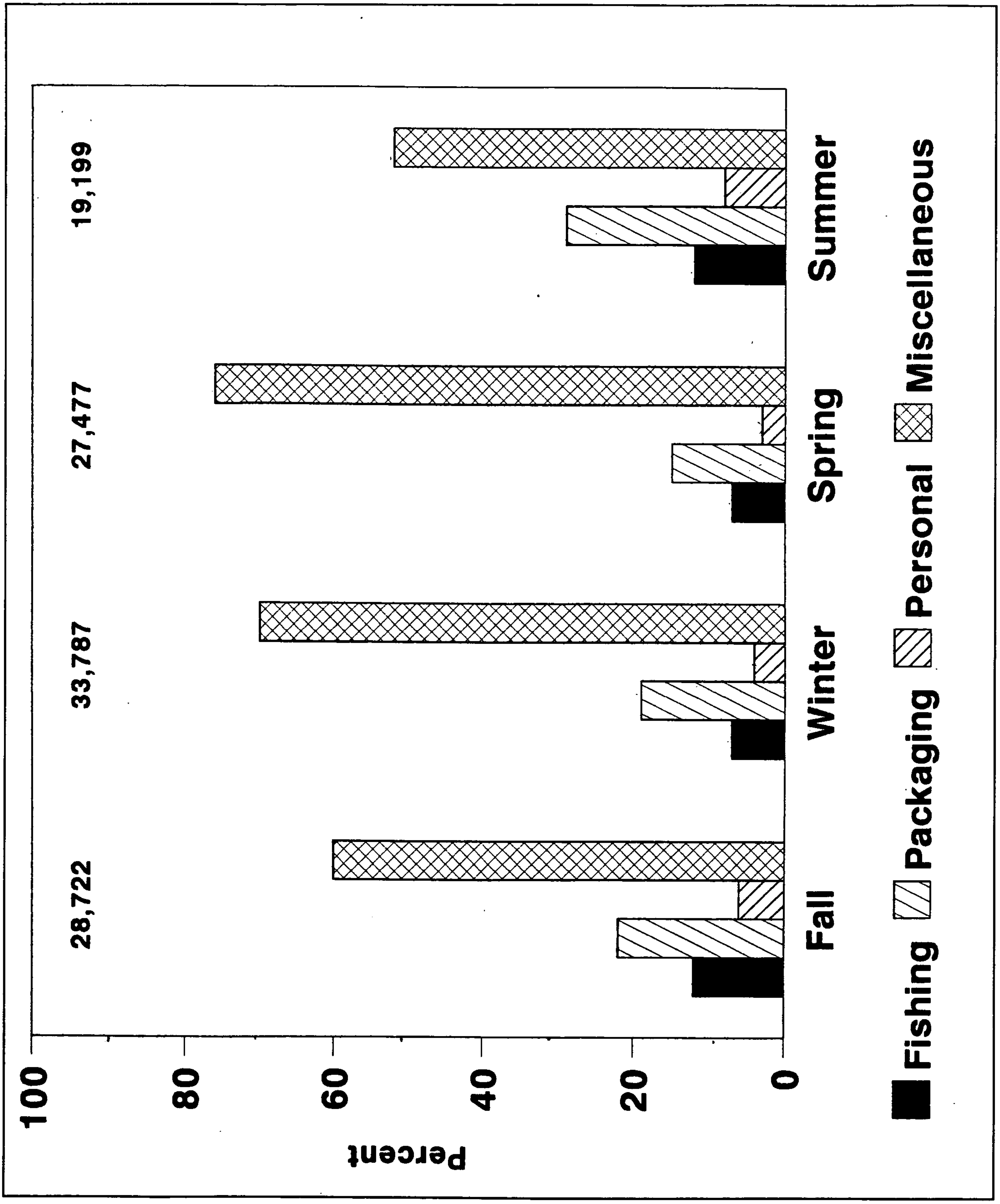

Figure 14. Percentage of plastic debris by category and season at seven national parks in 1992-93. Values above bars reflect total accumulation of plastic debris/km by season across all seven parks.

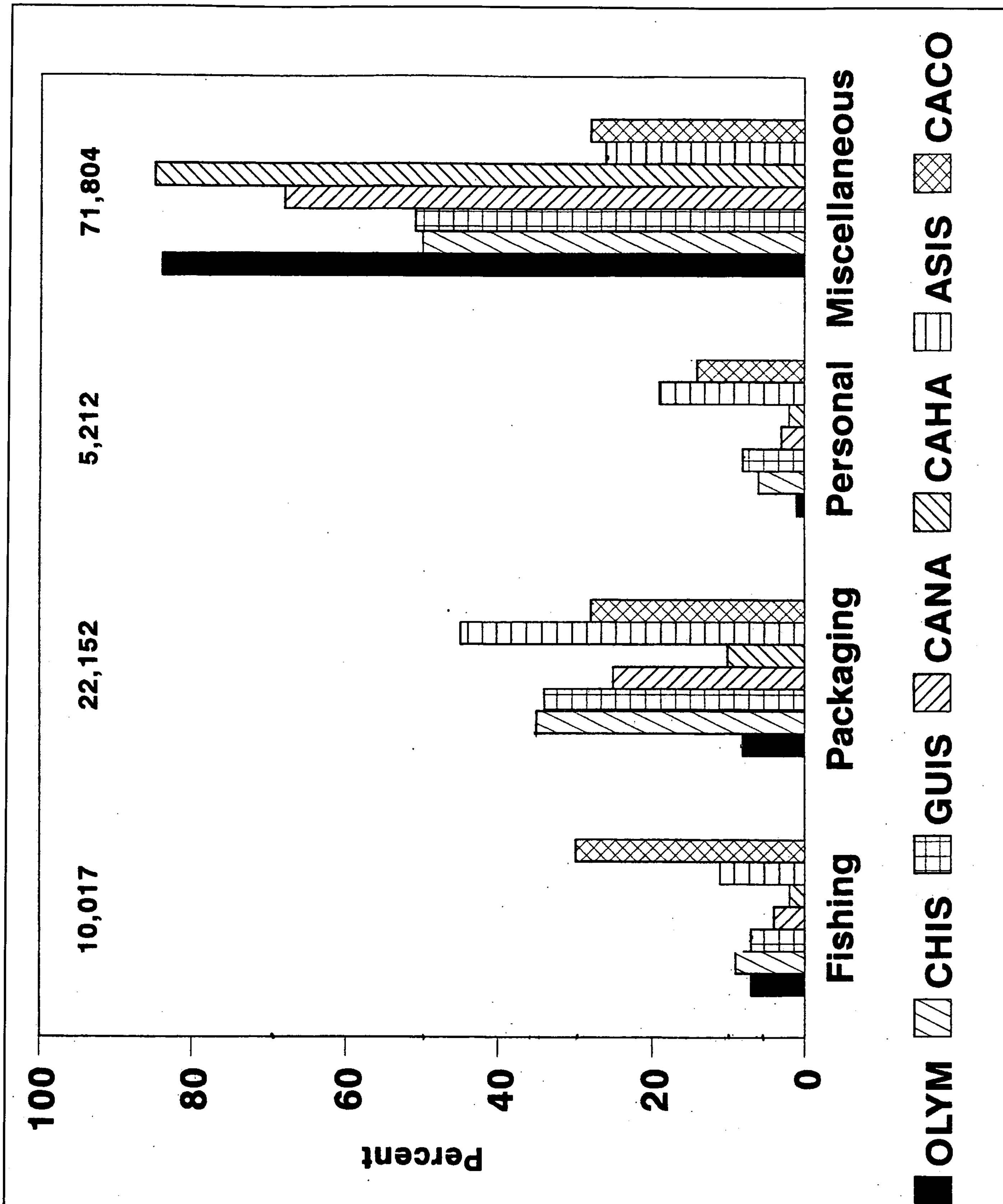

Figure 15. Percentage of plastic debris by category at seven national parks in 1992-93. Values above bars reflect total accumulation of plastic debris by category across all seven parks. OLYM = Olympic; CHIS = Channel Islands; GUIS = Gulf Islands; CANA = Canaveral; CAHA = Cape Hatteras; ASIS = Assateague; CACO = Cape Cod.

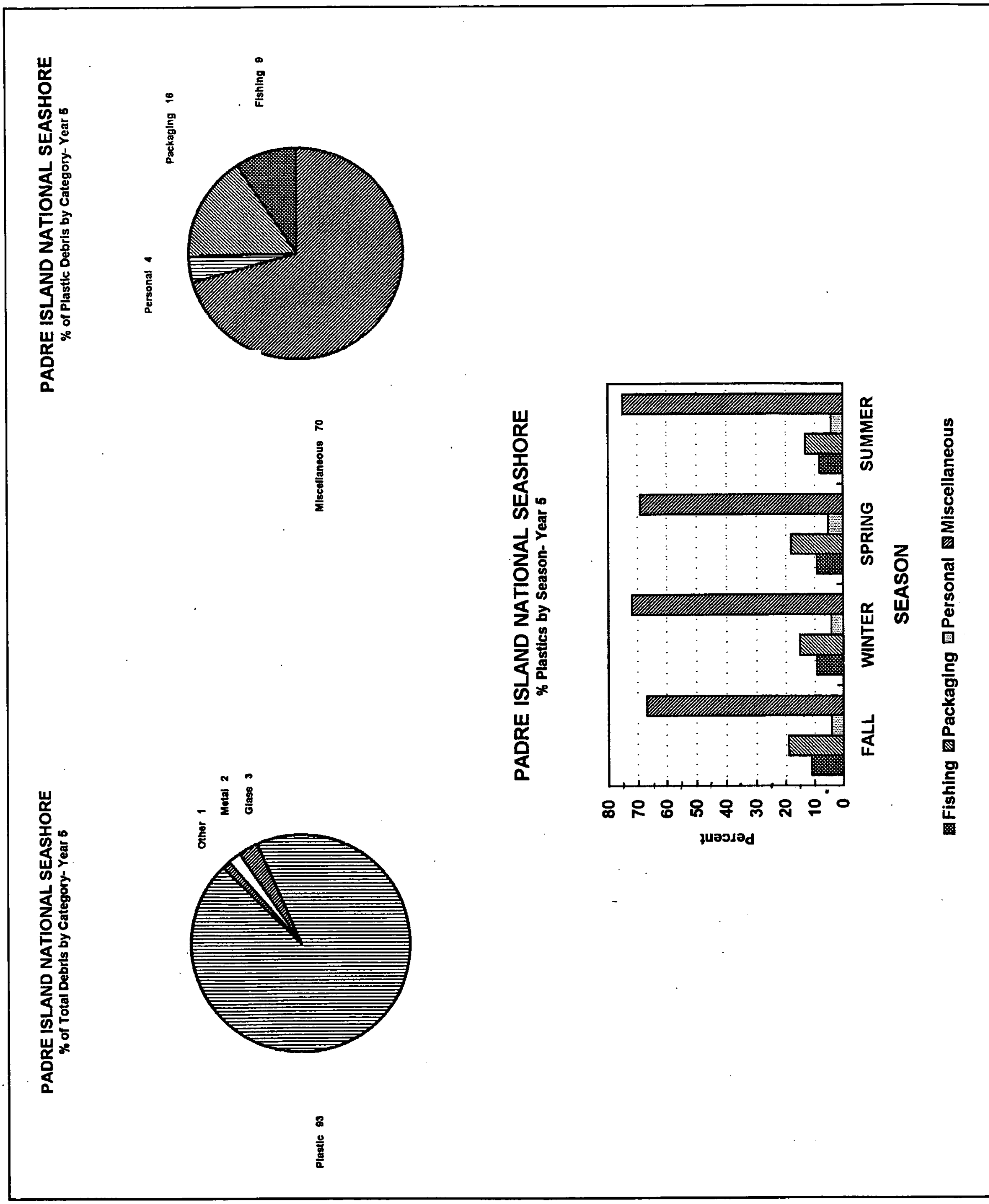

Figure 16. Percentage of total debris, plastic debris, and plastic debris by season at Padre Island National Seashore in 1992-93.

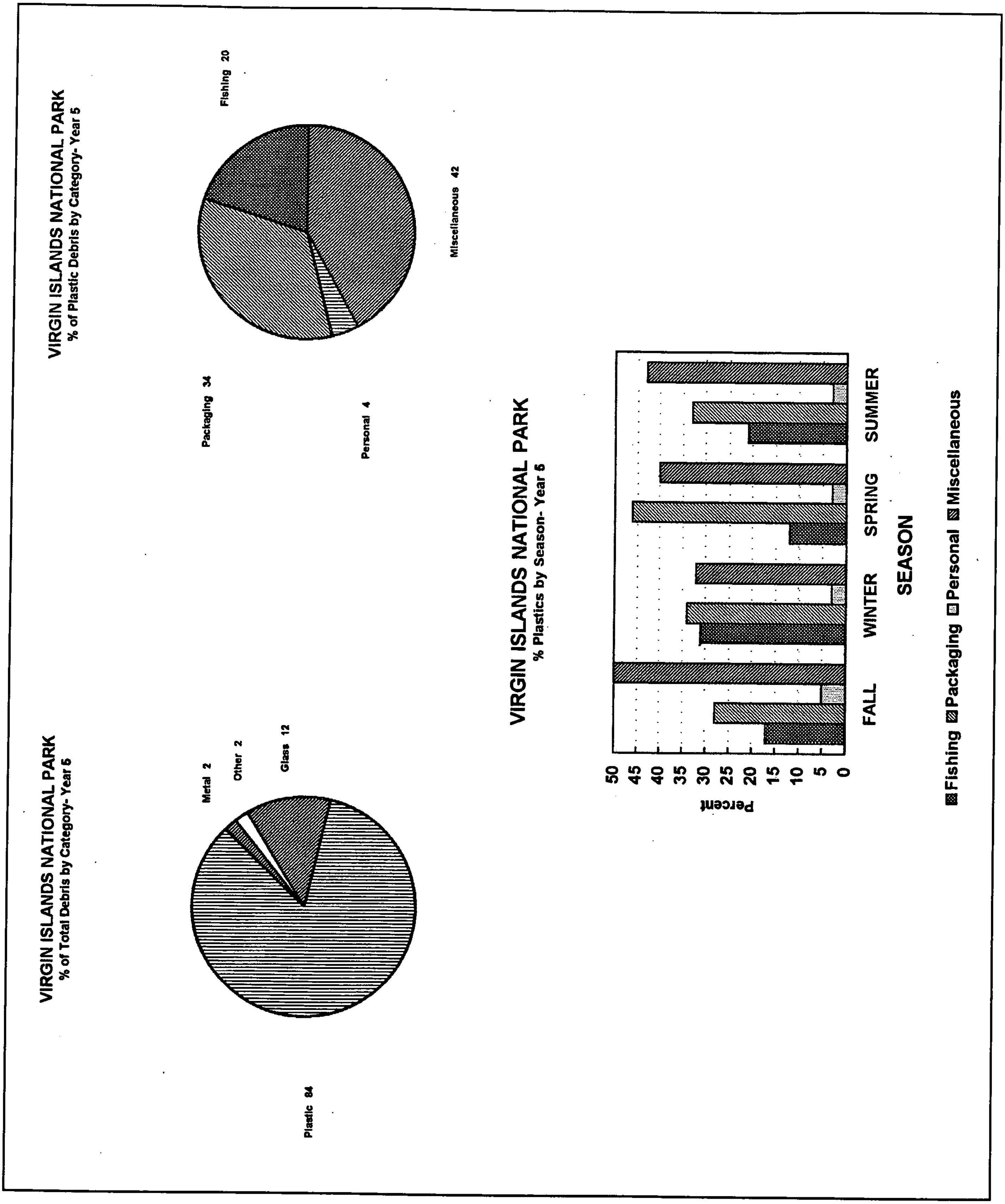

Figure 17. Percentage of total debris, plastic debris, and plastic debris by season at Virgin Islands National Park in 1992-93.

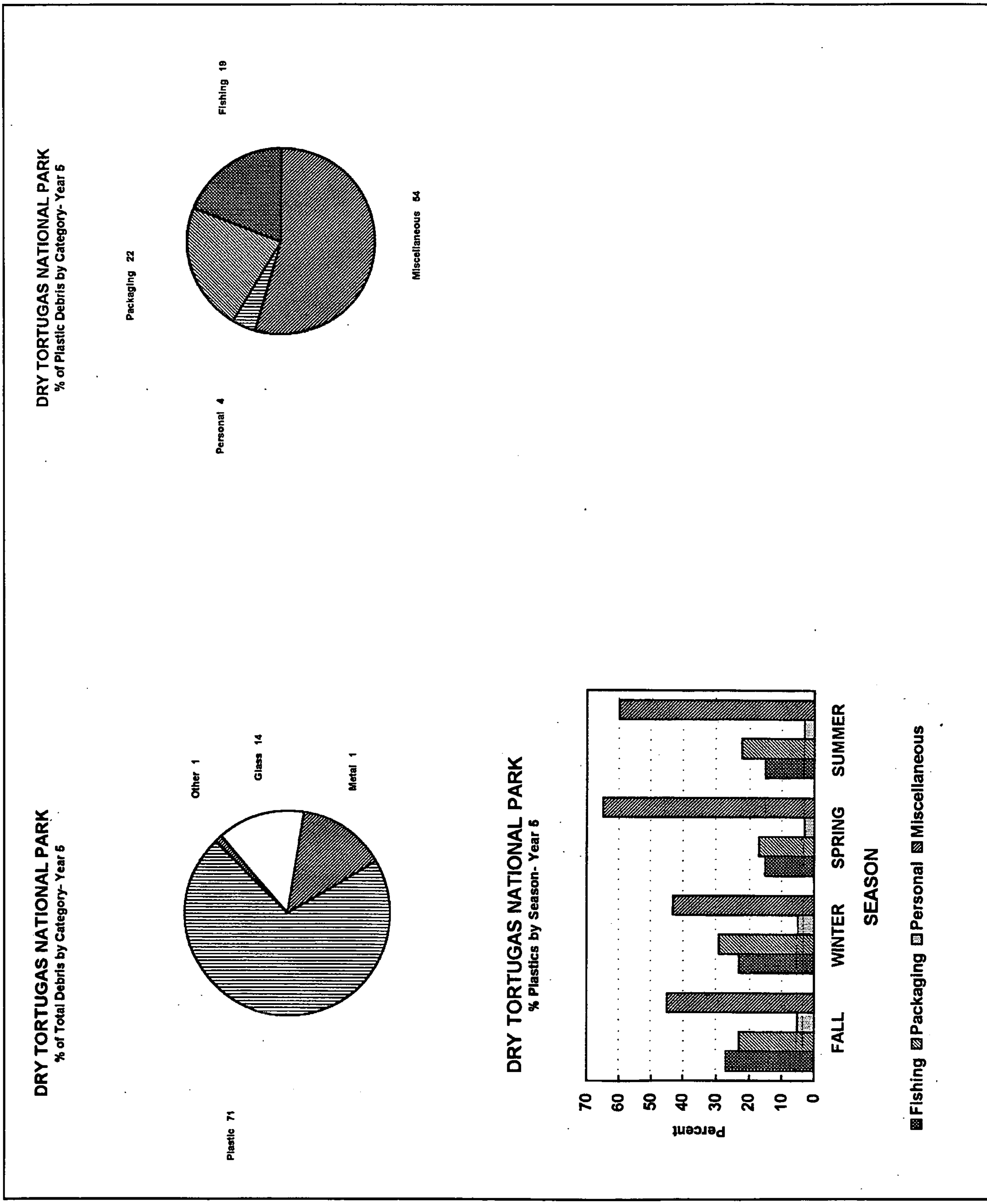

Figure 18. Percentage of total debris, plastic debris, and plastic debris by season at Dry Tortugas National Park in 1992-93.

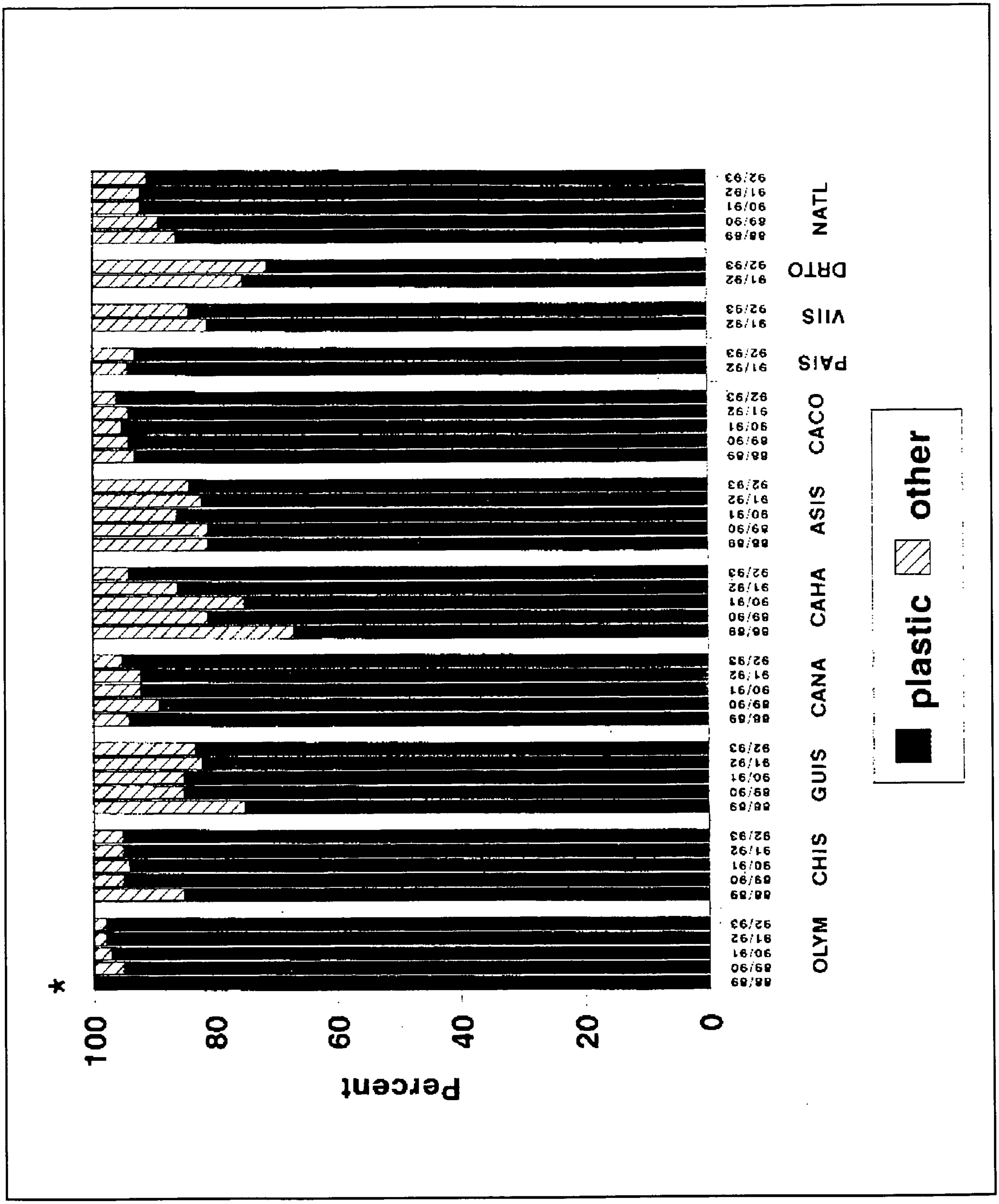

Figure 19. Percentage of plastic and other debris for seven national parks in 1988-89, 1989-90, 1990-91, 1991-92, and 1992-93. Olympic (OLYM) did not record nonplastic debris in 1988-89. Padre Island (PAIS), Virgin Islands (VIIS), and Dry Tortugas (DRTO) data is for 1991-92 and 1992-93 only.

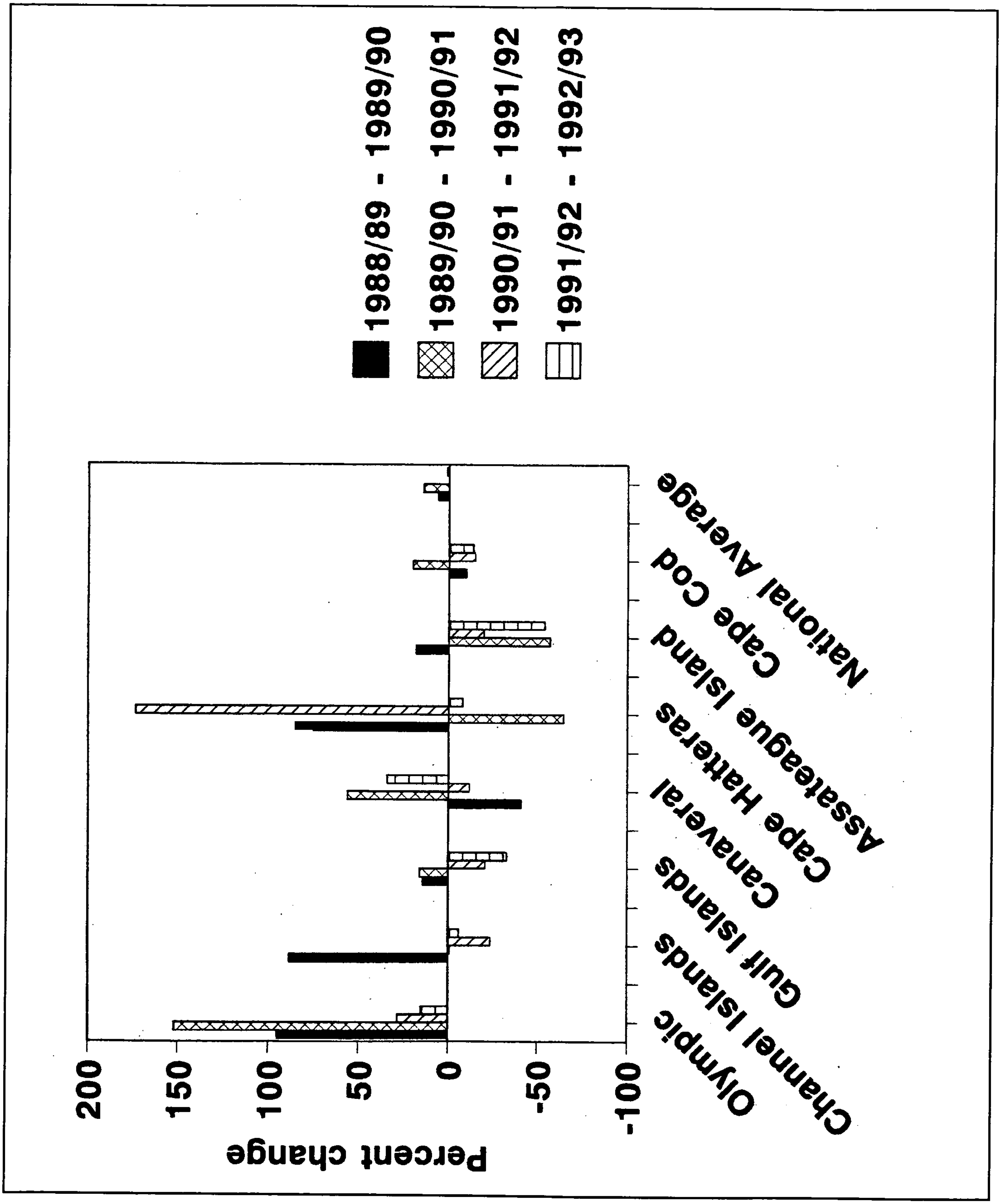

Figure 20. Percentage of change in average accumulation rates/km/quarter for total plastic in seven parks between 1988-89 1989-90, 1989-90-1990-91, 1990-91-1991-92, and 1991-92-1992 93.

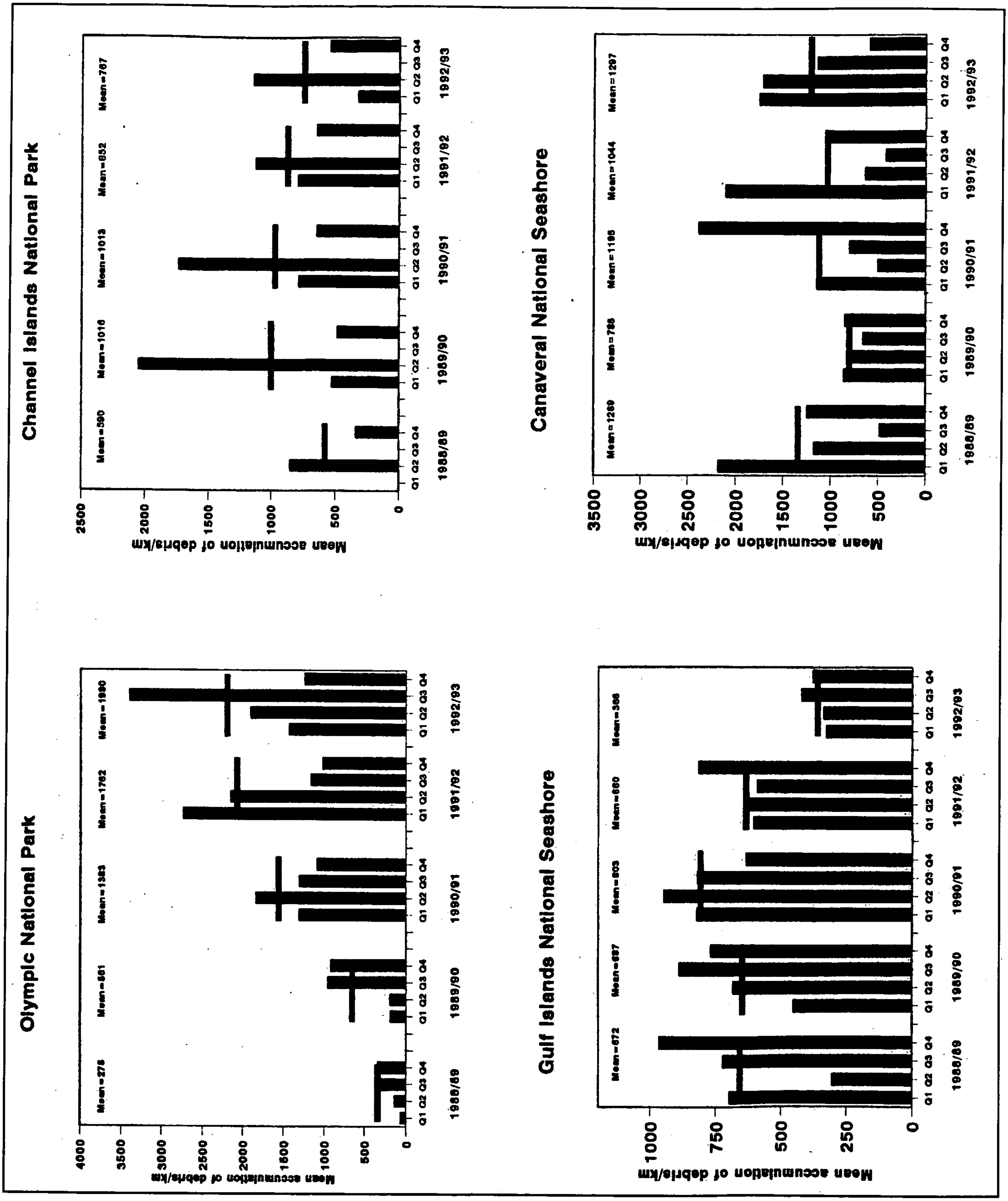

Figure 21 A. Quarterly comparison of accumulation rates of total debris (plastic and nonplastic) at seven parks and national average for 1988 89, 1989-90, 1990-91, 1991-92, and 1992-93. Solid horizontal bars show average quarterly accumulation rates (number/km) by year. Q1=Fall; Q2=Winter; Q3=Spring; Q4=Summer.

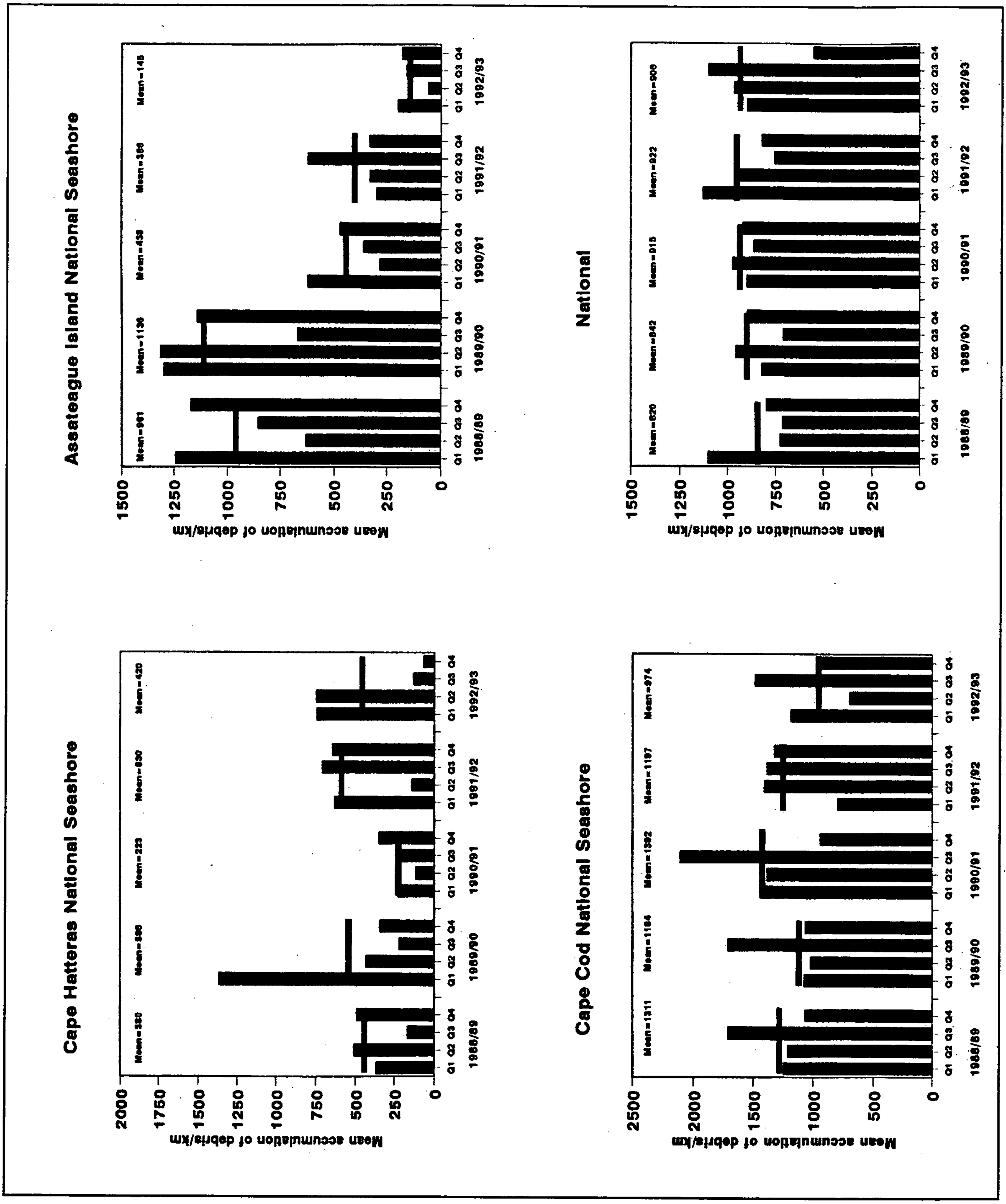

Figure 21 B. Quarterly comparison of accumulation rates of total debris (plastic and nonplastic) at seven parks and national average for 1988 89, 1989-90, 1990-91, 1991-92, and 1992-93. Solid horizontal bars show average quarterly accumulation rates (number/km) by year. Q1=Fall; Q2=Winter; Q3=Spring; Q4=Summer.

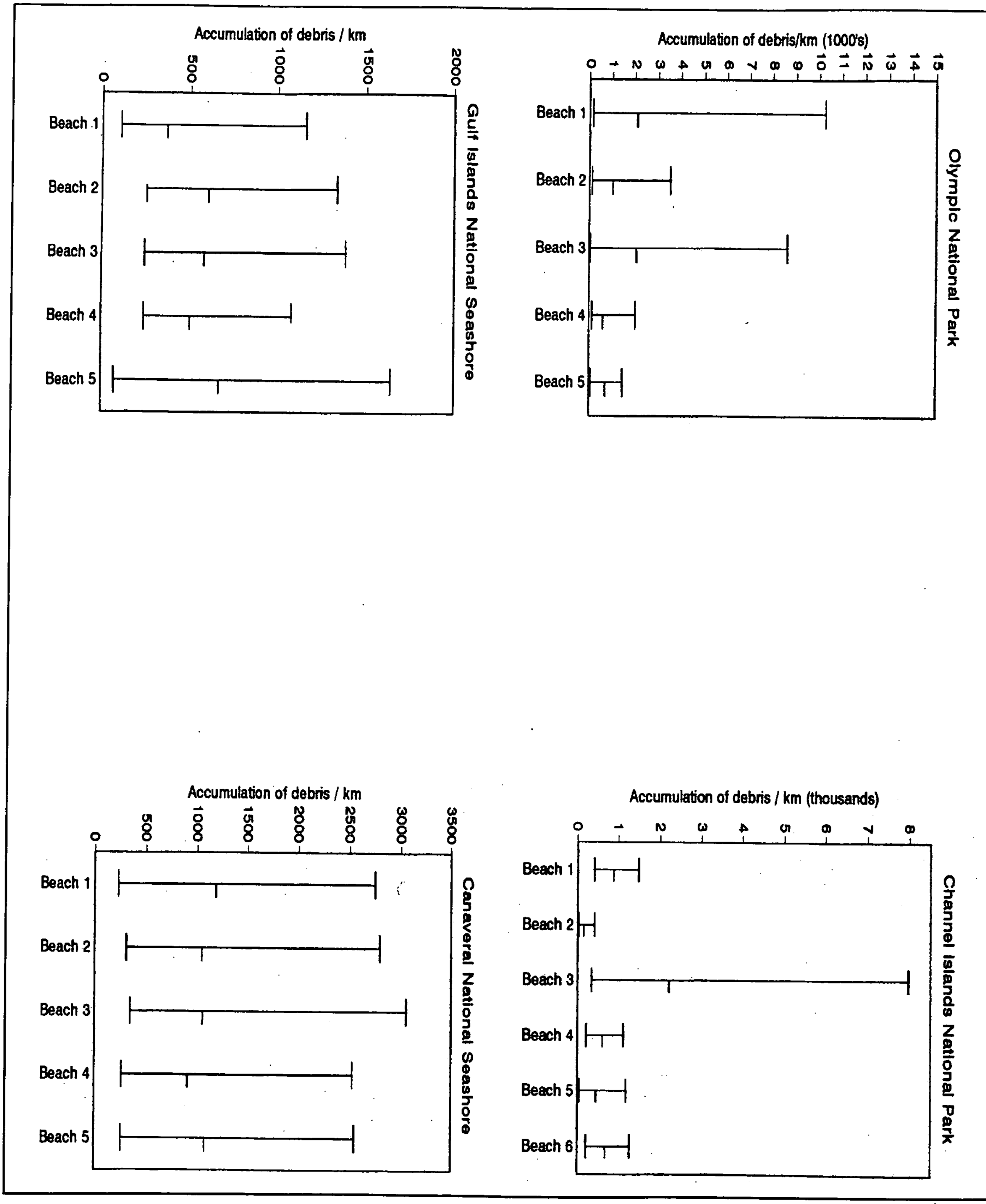

Figure 22 A. Variability in accumulation rates of total debris for seven parks by survey beach. Length of bar indicates range in quarterly debris accumulation; tick mark indicates the mean of five years of quarterly surveys.

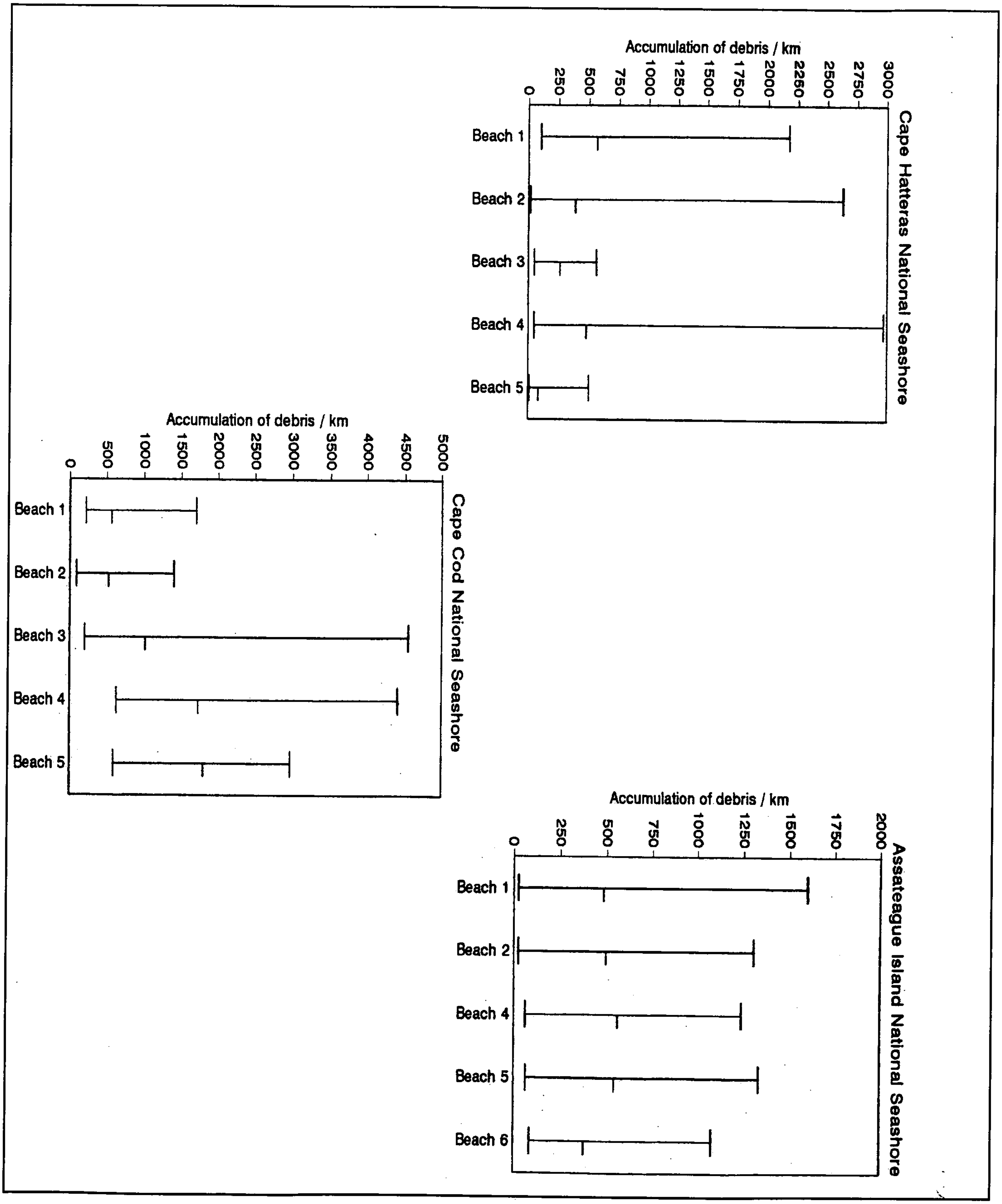

Figure 22 B. Variability in accumulation rates of total debris for seven parks by survey beach. Length of bar indicates range in quarterly debris accumulation; tick mark indicates the mean of five years of quarterly surveys.

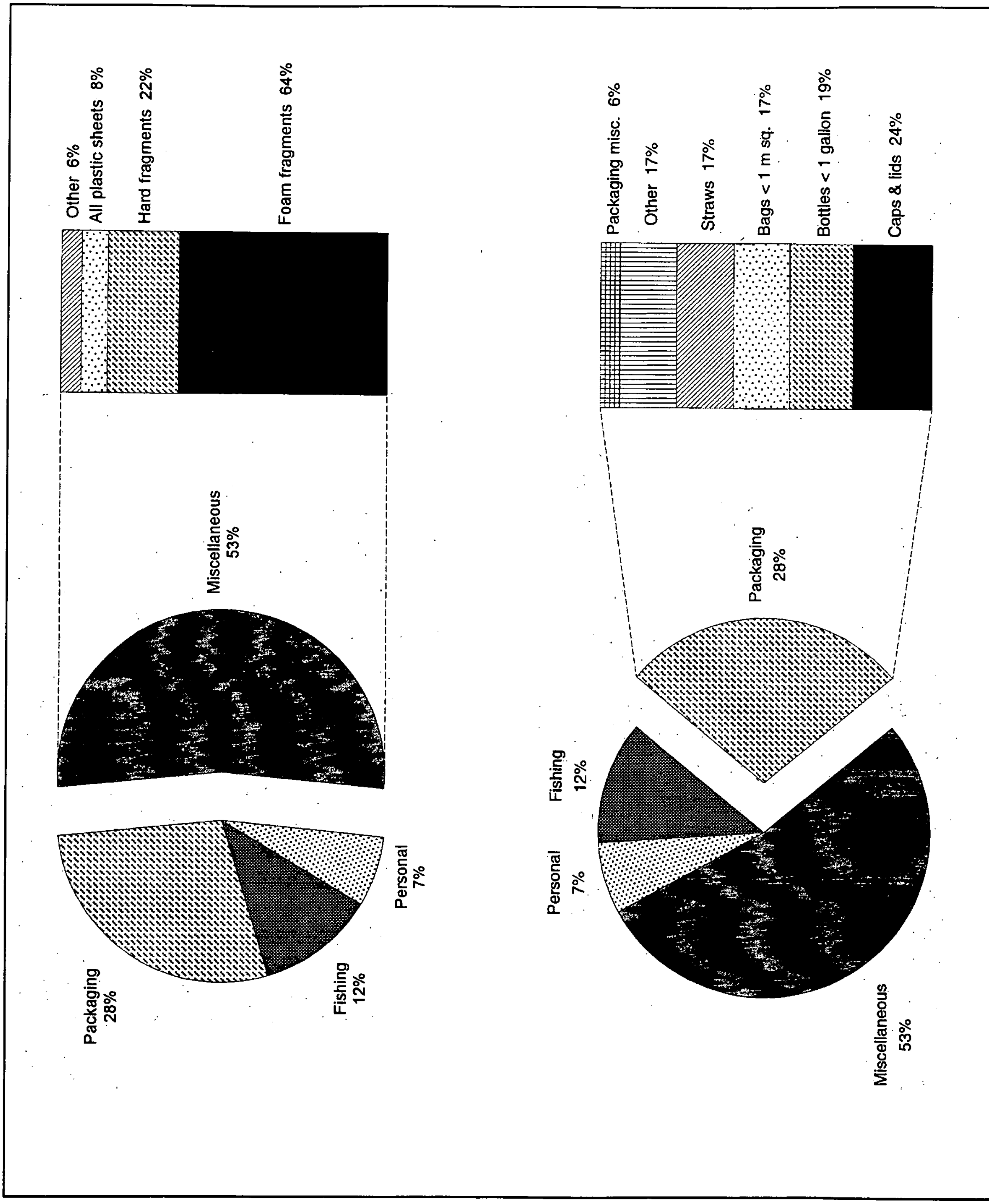

Figure 23. Composition plastic debris for 1988-1993 for all parks combined, except Padre Island National Seashore, Virgin Islands National Park, and Dry Tortugas National Park. Sidebars indicate specific breakdown of miscellaneous and packaging plastics, respectively.

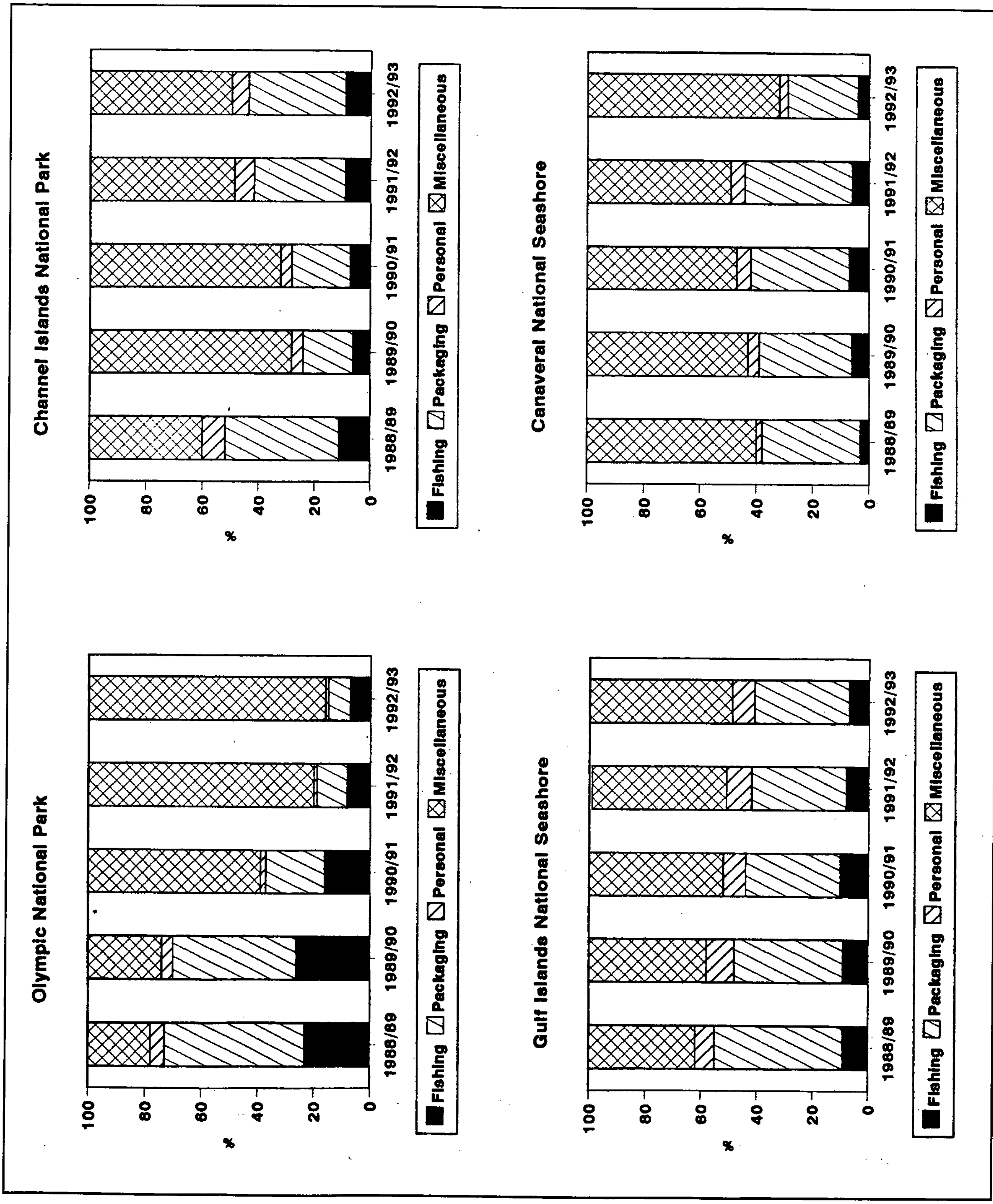

Figure 24 A. Composition of plastic debris for seven national parks and national average for 1988-89, 1989-90, 1990-91, and 1992-93.

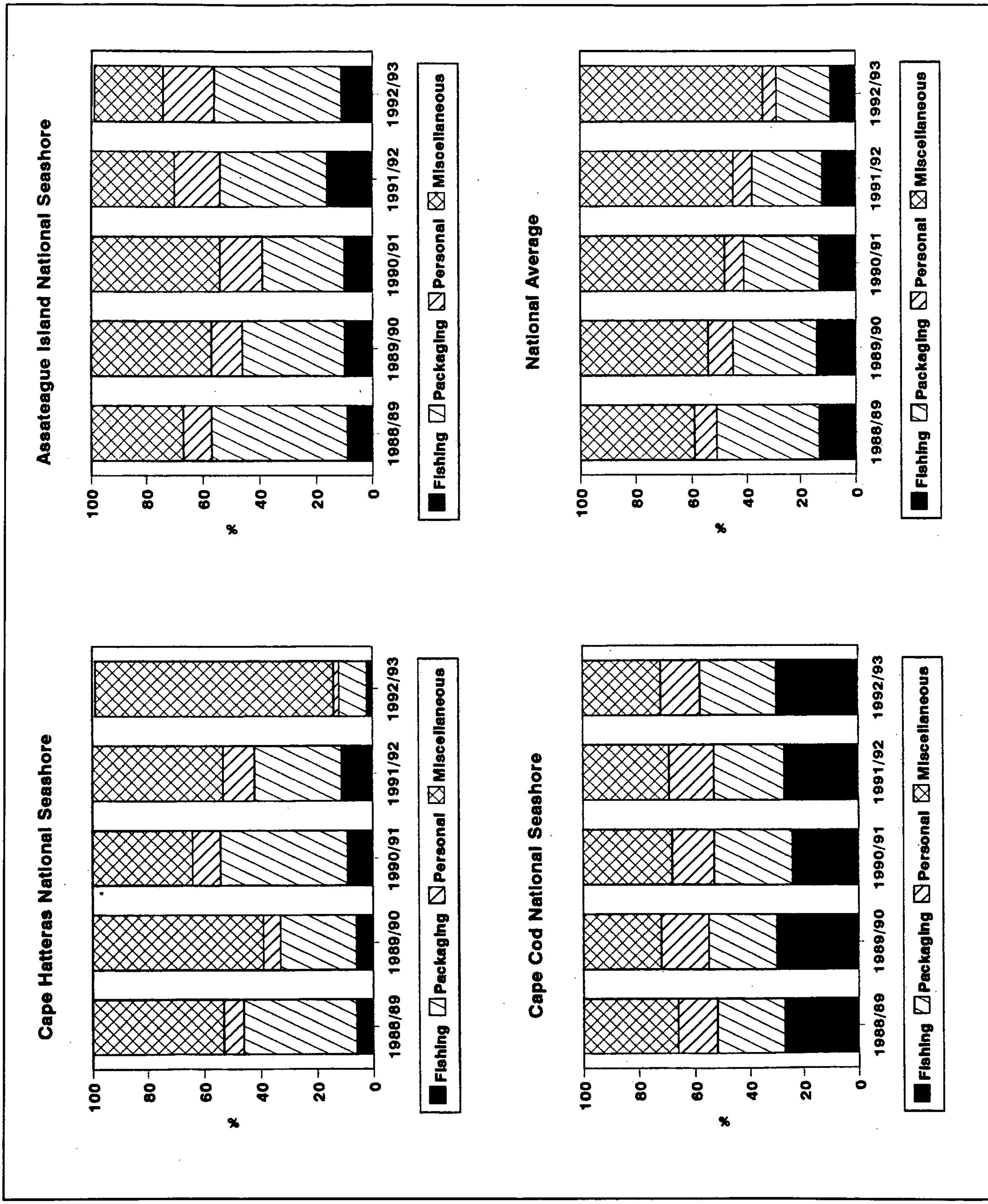

Figure 24 B. Composition of plastic debris for seven national parks and national average for 1988-89, 1989-90, 1990-91, and 1992-93.

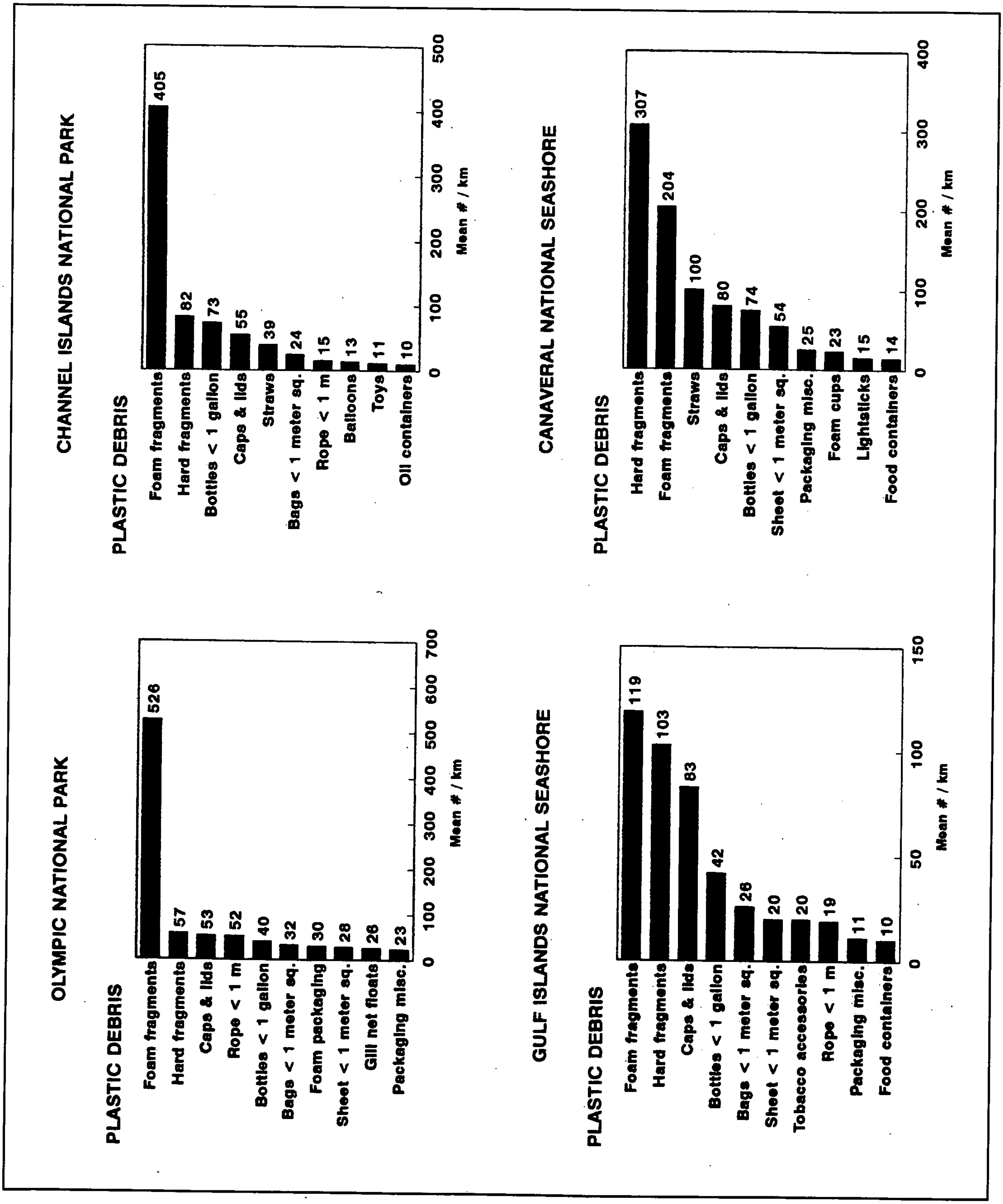

Figure 25 A. Ten most abundant plastic debris items for seven national parks and national average for 1988-**93.A.** Ten most abundant plastic debris items for seven national parks and national average for 1988-93.

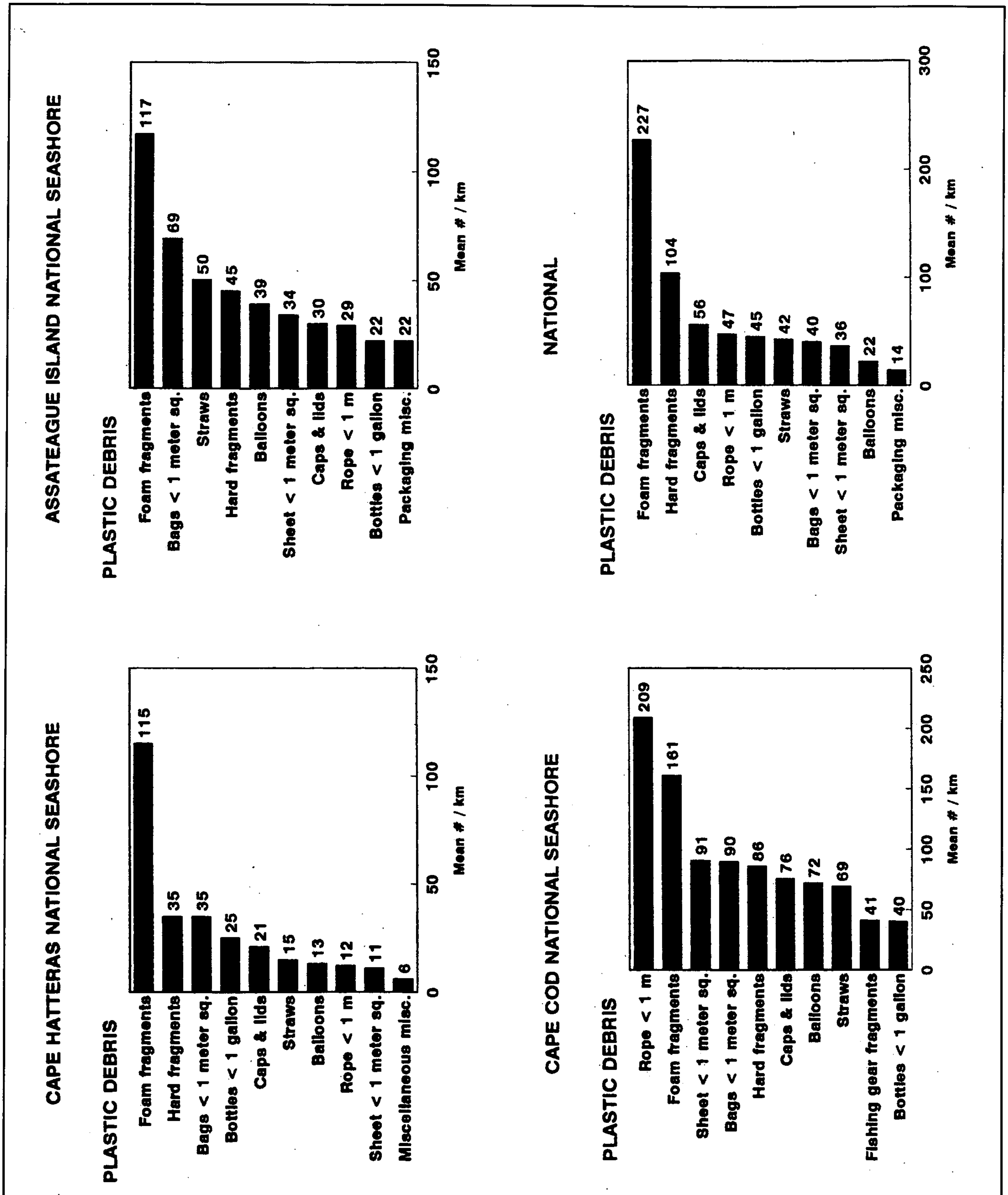

Figure 25 B. Ten most abundant plastic debris items for seven national parks and national average for 1988-93.

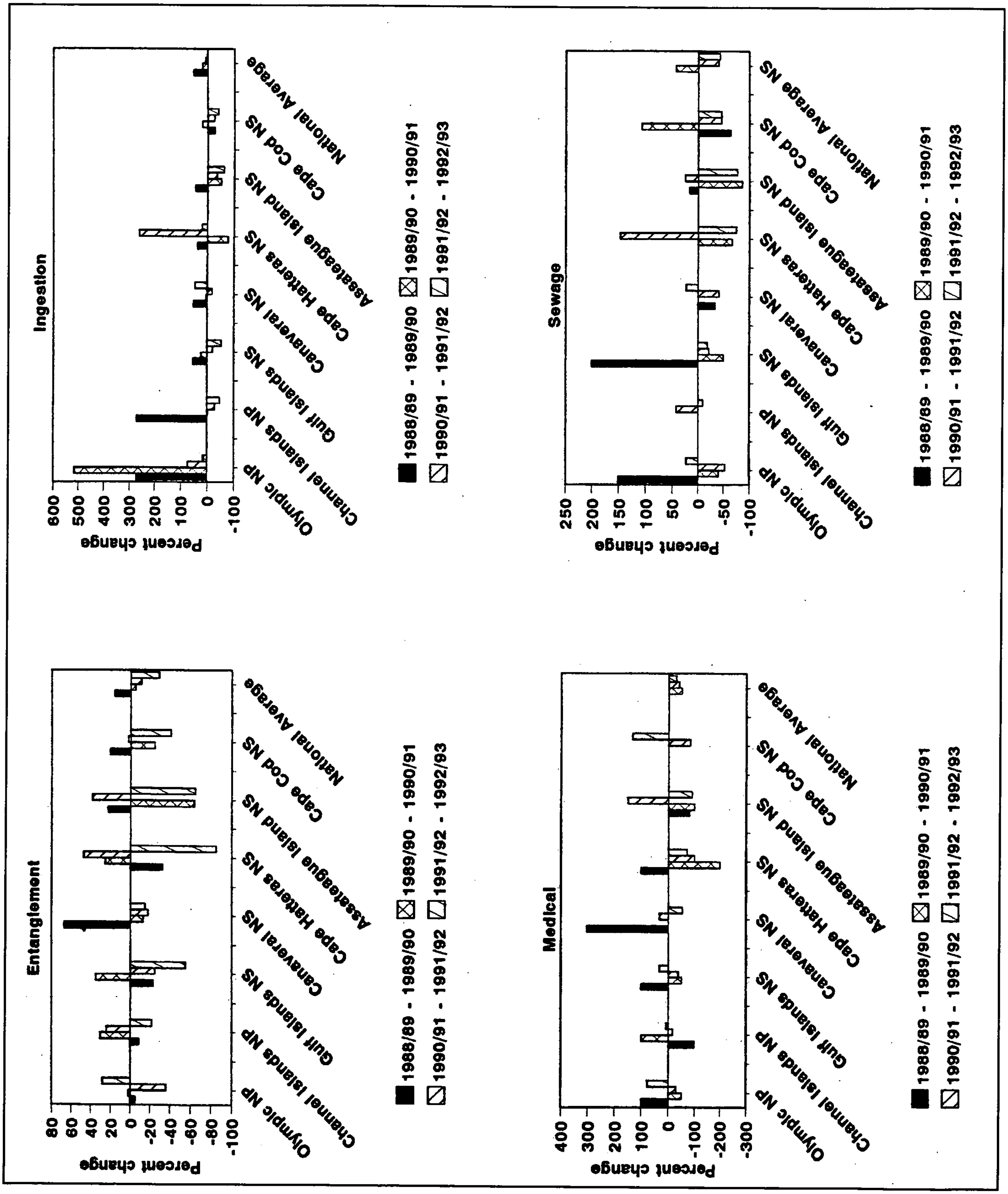

Figure 26. Change in mean accumulation rates (items/km/quarter) for selected debris categories at seven parks between 1988-89-1989-90, 1989-90-1990-91, 1990-91-1991-92, and 1991-92-1992-93. National average does not include data from Padre Island National Seashore, Virgin Islands National Park, and Dry Tortugas National Park. Values which appear missing are near or equal to zero.

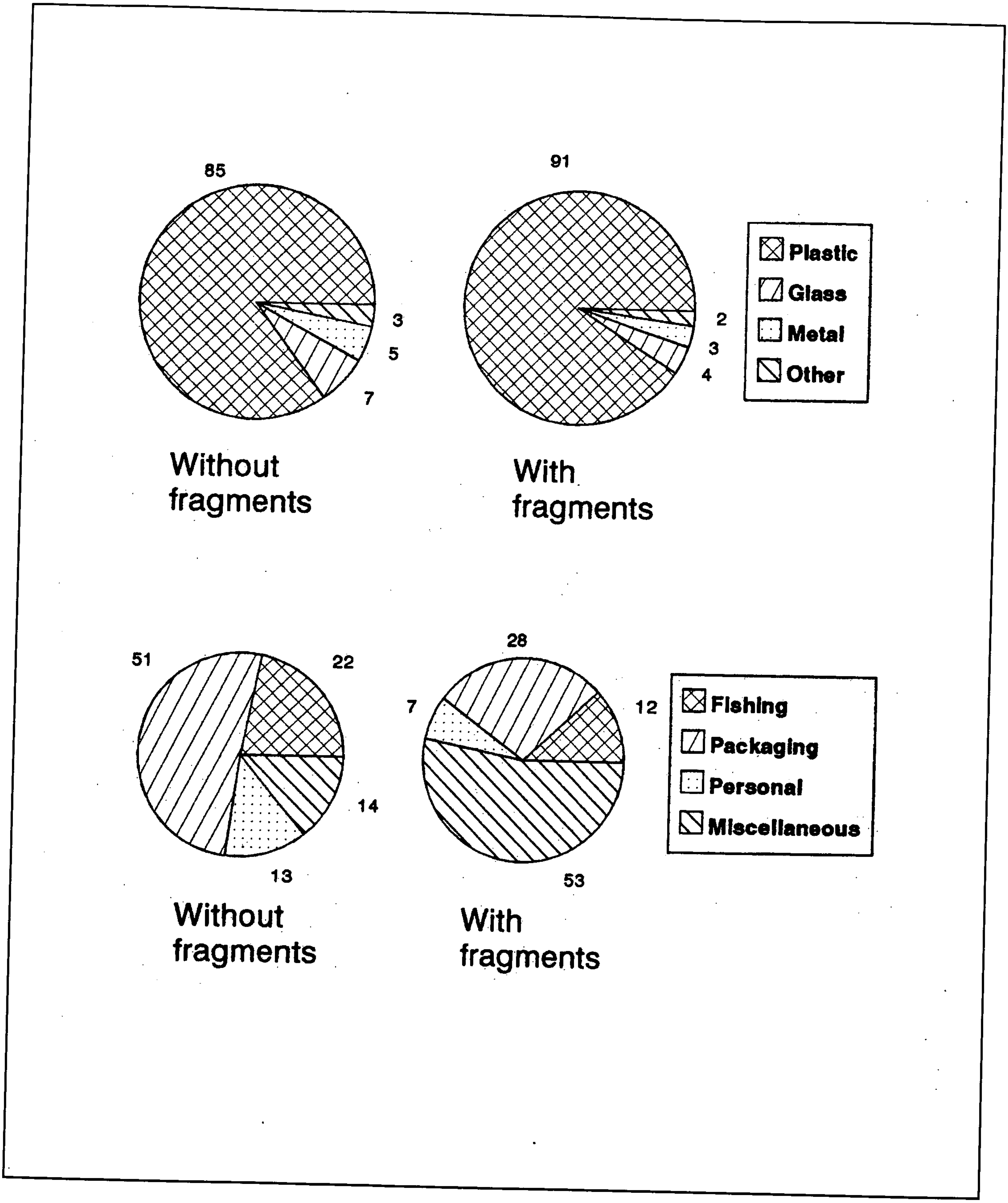

Figure 27. Comparison of the composition of total debris and plastic debris with and without the influence of foam and hard fragments for 1988-93. Values adjacent to pie slices are percentages.

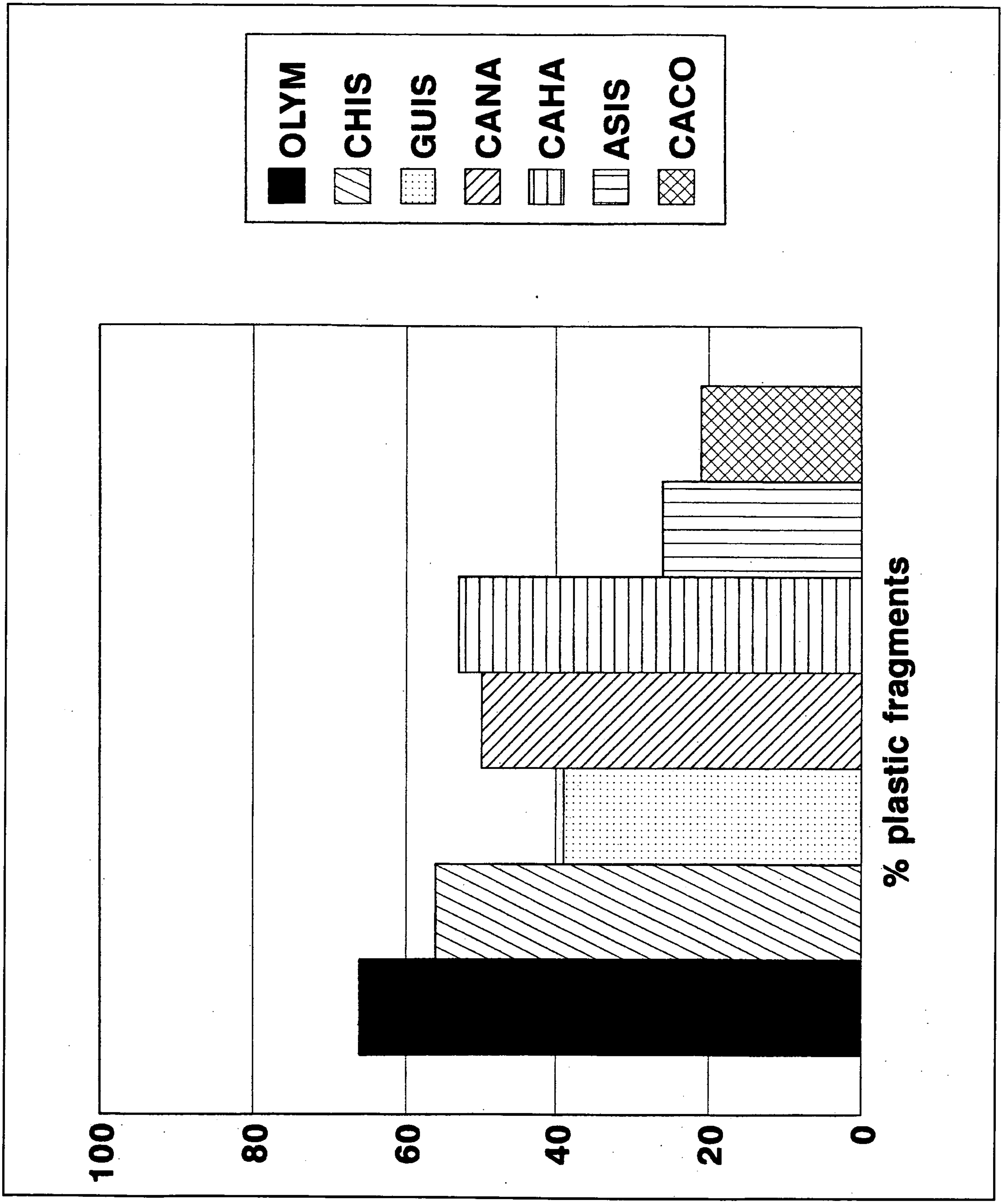

Figure 28. Percentage of composition of plastic debris composed of foam and hard fragments for seven national parks for 1988-93.

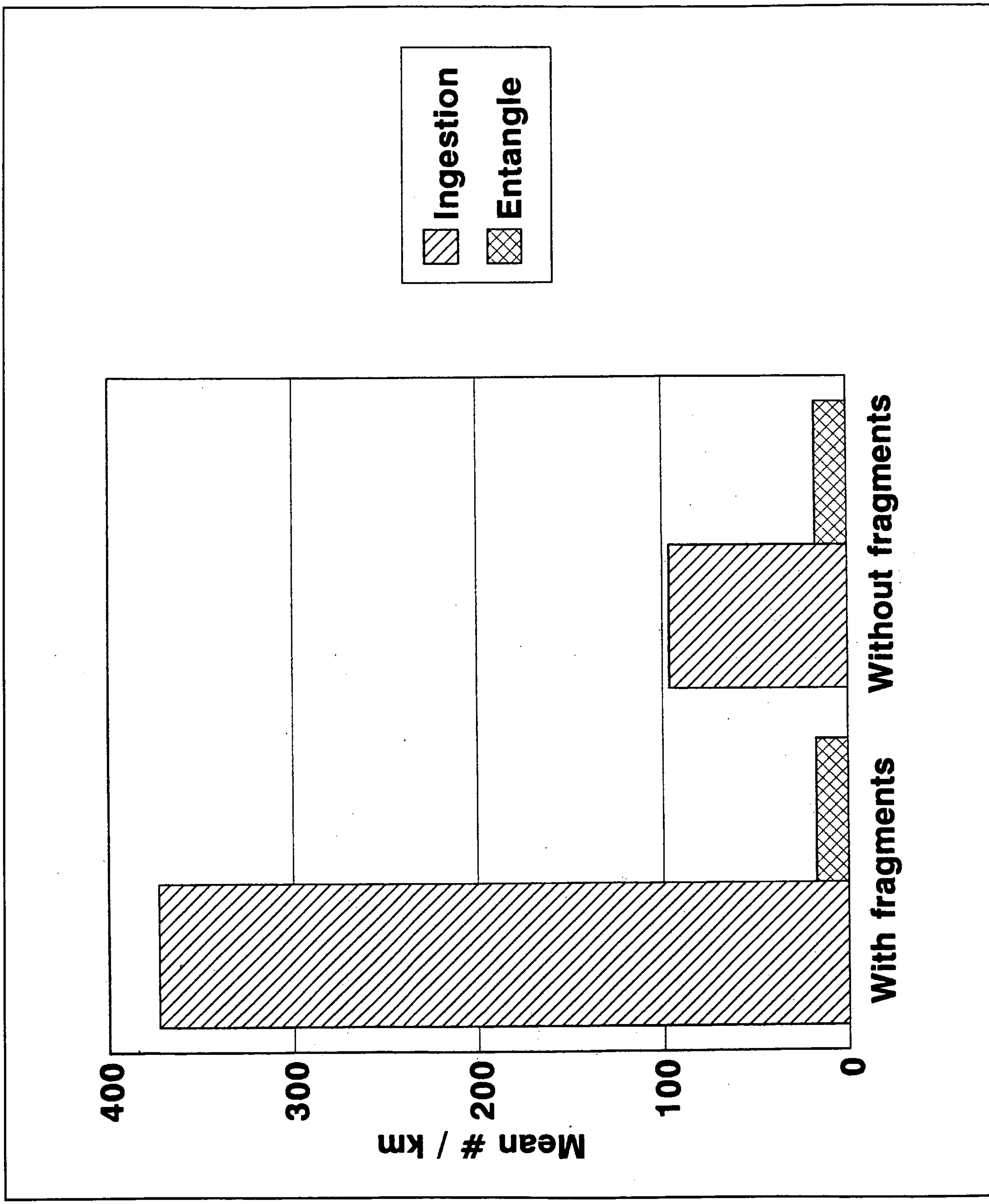

Figure 29. Differential accumulation rates of ingestible debris with and without the influence of foam and hard fragments in 1988-93.

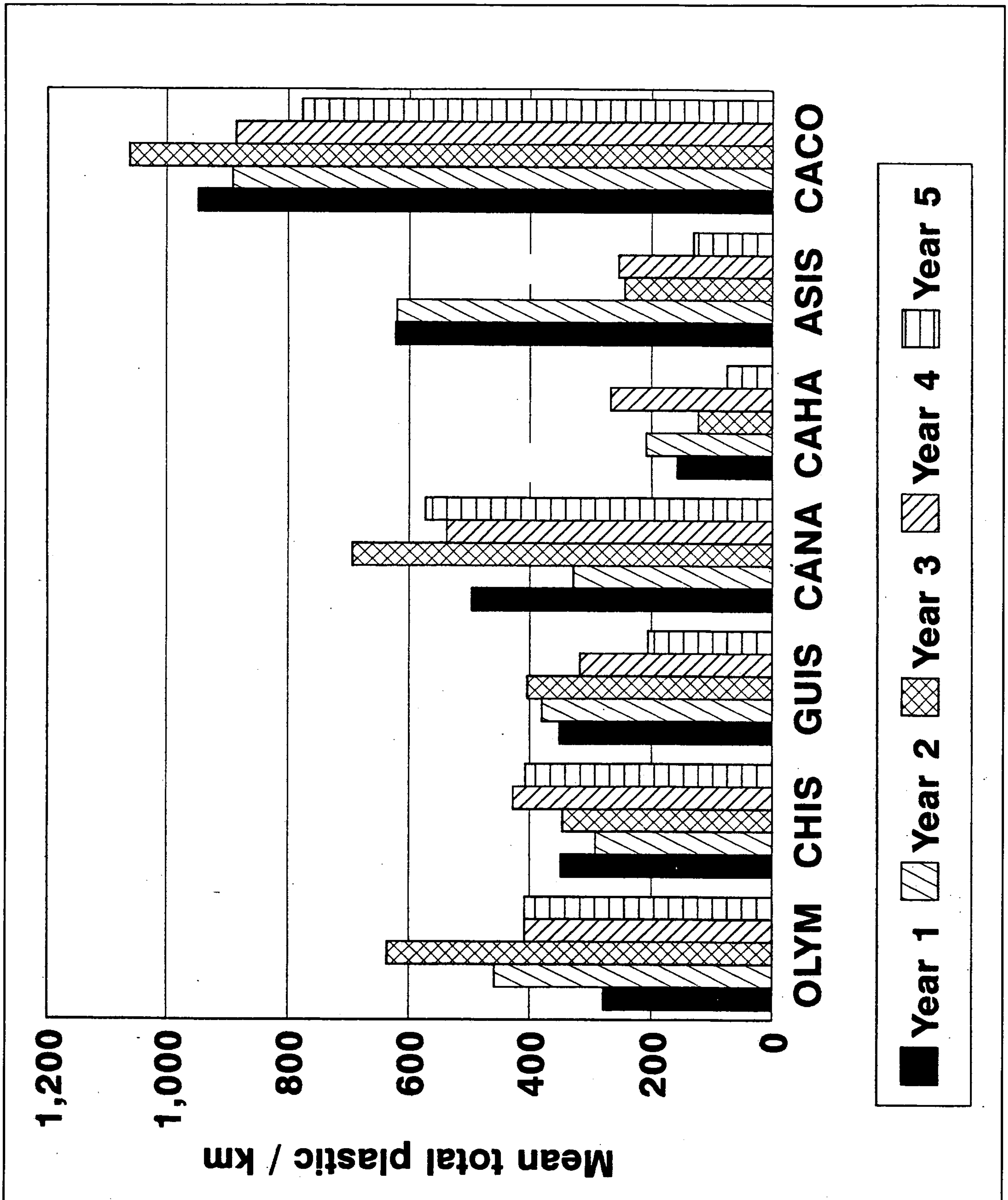

Figure 30. Total yearly plastic accumulation rates without the influence of foam and hard fragments for seven parks in 1988-93.

TABLES

Table 1. Average quarterly accumulation rate of marine debris (number/km) at ten national parks in 1992-93. NATL is the average quarterly accumulation rate for all parks combined, except Padre Island National Seashore, Virgin Islands National Park, and Dry Tortugas National Park. Values given may not equal those shown on figures 13 and 21 due to rounding.

Plastic Fishing Gear

	OLYM	CHIS	PAIS	GUIS	CANA	CAHA	ASIS	CACO	VIIS	DRTO	NATL
Trawl net	2	TR	1	TR	TR	TR	TR	4	2	1	1
Monofilament gill nets	1	TR	0	0	1	0	TR	1	0	0	TR
Multifilament gill nets	TR	TR	0	TR	TR	0	0	0	0	0	TR
Rope >1 m	9	6	111	4	2	1	2	9	154	5	5
Rope <1 m	43	13	1025	11	11	4	5	182	494	13	34
Monofilament fishing line	14	TR	15	1	TR	TR	1	1	3	1	3
Loops of rope	1	3	0	1	TR	0	TR	TR	TR	2	1
Open straps	4	5	68	2	5	1	TR	9	60	3	4
Closed straps	1	2	5	TR	TR	0	TR	1	2	TR	1
Trawl floats	TR	3	1	1	2	TR	0	TR	TR	1	1
Gillnet floats	30	11	1	TR	2	TR	TR	1	0	2	6
Crab pot floats	2	9	0	1	5	TR	TR	2	3	40	3
Buoy bags	1	TR	0	0	TR	0	0	0	0	0	TR
Other floats	4	7	1	1	2	1	1	2	4	2	2
Oil containers	0	17	0	0	3	0	TR	0	0	1	2
Fish baskets	1	TR	0	TR	2	0	0	TR	0	0	1
Bait containers	1	3	0	0	0	0	TR	7	0	0	1
Lures	2	1	3	1	TR	TR	1	3	TR	1	1
Ampules	0	0	2	TR	1	0	0	0	1	0	TR
Light sticks	0	1	143	4	6	1	0	TR	9	7	2
Fishing gear fragments	21	1	72	TR	1	0	3	61	11	1	11
Miscellaneous	3	2	1	TR	1	TR	1	10	4	1	2
Total	140	84	1449	27	44	8	14	293	747	81	81

Table 1 (Continued)

Plastic Personal

	OLYM	CHIS	PAIS	GUIS	CANA	CANA	ASIS	CACO	VIIS	ORTO	NATL
Hats	TR	TR	1	TR	1	TR	TR	TR	1	1	TR
Footwear	4	4	53	3	10	1	2	4	12	2	4
Gloves	1	1	53	2	TR	TR	TR	2	2	1	1
Tobacco accessories	5	6	368	13	4	2	4	21	51	5	7
Toys	4	13	58	2	4	1	3	5	4	1	4
Balloons	1	12	115	5	14	4	14	60	12	1	14
Combs	1	2	28	2	2	TR	1	1	6	1	1
Tampons	2	1	5	1	1	1	TR	20	7	1	3
Cotton swabs	0	2	0	TR	1	TR	0	7	3	TR	1
Condoms	TR	0	1	TR	TR	0	0	0	0	0	TR
Syringes	TR	TR	5	TR	TR	TR	0	TR	1	1	TR
Crack vials	0	0	1	0	TR	0	0	0	0	0	TR
Miscellaneous	3	5	15	1	7	TR	2	13	45	1	4
Total	21	46	703	29	44	9	26	133	144	15	39

Table 1 (Continued)

Plastic Personal

	OLYM	CHIS	PAIS	GUIS	CANA	CANA	ASIS	CACO	VIIS	DRTO	NATL
Hats	TR	TR	1	TR	1	TR	TR	TR	1	1	TR
Footwear	4	4	53	3	10	1	2	4	12	2	4
Gloves	1	1	53	2	TR	TR	TR	2	2	1	1
Tobacco accessories	5	6	368	13	4	2	4	21	51	5	7
Toys	4	13	58	2	4	1	3	5	4	1	4
Balloons	1	12	115	5	14	4	14	60	12	1	14
Combs	1	2	28	2	2	TR	1	1	6	1	1
Tampons	2	1	5	1	1	1	TR	20	7	1	3
Cotton swabs	0	2	0	TR	1	TR	0	7	3	TR	1
Condoms	TR	0	1	TR	TR	0	0	0	0	0	TR
Syringes	TR	TR	5	TR	TR	TR	0	TR	1	1	TR
Crack vials	0	0	1	0	TR	0	0	0	0	0	TR
Miscellaneous	3	5	15	1	7	TR	2	13	45	1	4
Total	21	46	703	29	44	9	26	133	144	15	39

Table 1 (Continued)

Plastic Miscellaneous

	OLYN	CHIS	PAIS	GUIS	CANA	CAHA	ASIS	CACO	VIIS	DRTO	NATL
Sheet <1 m sq	14	11	2482	17	132	5	11	50	134	9	35
Sheet >1 m sq	TR	TR	15	2	1	TR	1	TR	5	2	1
Shotgun	6	3	26	2	2	2	1	21	2	1	5
Pipes	9	2	68	1	2	1	TR	1	13	2	2
Pipe thread protectors	TR	TR	3	TR	TR	TR	0	0	0	0	TR
Brushes	TR	TR	4	1	0	TR	0	TR	1	TR	TR
Trash cans	TR	TR	0	TR	TR	TR	TR	0	0	TR	TR
Tires	4	TR	0	TR	0	TR	5	TR	13	0	1
Write protection rings	0	TR	0	0	0	0	0	0	0	0	TR
Hard hats	TR	1	1	TR	0	0	TR	0	0	0	TR
Hard fragments	63	109	5273	62	162	5	6	95	1154	59	72
Foam fragments	1520	251	3102	98	562	332	9	96	175	141	435
Pellets	1	0	0	TR	2	0	0	7	0	7	1
Gaskets	4	3	137	2	4	0	TR	3	49	3	2
Miscellaneous	44	2	55	1	11	3	5	1	26	0	10
Medical	TR	1	8	TR	1	0	TR	TR	3	0	TR
Oil and gas	0	0	28	0	TR	0	0	0	0	0	TR
Total	1665	383	11202	186	879	348	38	274	1575	224	564

Table 1 (Continued)

Nonplastic

	OLYM	CHIS	PAIS	GUIS	CANA	CAHA	ASIS	CACO	VIIS	DRTO	NATL
Glass bottles	6	13	98	19	30	7	4	10	33	22	13
Glass bulbs	1	4	24	7	10	2	8	1	3	25	4
Glass medical	1	TR	1	TR	TR	0	0	0	TR	TR	TR
Glass pieces	10	0	453	3	1	3	8	3	480	32	4
Glass miscellaneous	TR	TR	0	1	TR	0	TR	1	11	TR	3
Total Glass	18	17	576	30	41	12	20	15	527	79	24
Metal caps	1	TR	15	1	6	TR	TR	1	11	4	1
Metal propane	0	1	1	TR	TR	0	TR	TR	0	TR	TR
Metal 55 gal drums	0	TR	0	TR	0	0	TR	0	0	0	TR
Metal beverage cans	4	5	139	18	4	4	6	7	49	61	7
Metal other cans	3	5	24	8	8	1	1	2	3	16	4
Metal wire	1	TR	9	1	TR	TR	1	TR	1	1	TR
Metal crab cages	0	TR	0	0	TR	0	0	0	0	0	TR
Metal pieces	1	1	136	20	4	1	1	3	11	1	3
Metal miscellaneous	3	1	13	2	1	TR	1	1	22	1	1
Total Metal	13	13	337	50	23	6	10	14	97	84	16
Paper	1	6	187	8	6	7	12	9	100	3	6
Cloth	7	TR	27	1	1	2	3	3	5	1	2
Leather	0	0	0	TR	TR	TR	0	TR	1	1	TR
Total Nonplastic	39	36	1,127	89	71	27	45	41	730	168	48
Total Plastic	1991	782	15,913	366	1294	408	143	974	3,730	410	858

Table 2. Types and average quarterly accumulation rates (number/km) of plastic entanglement debris at ten national parks in 1992-93. NATL is the average quarterly accumulation rate for all parks combined, except Padre Island National Seashore, Virgin Islands National Park, and Dry Tortugas National Park . Nets includes trawl nets and mono- and multifilament gill nets.

	OLYM	CHIS	PAIS	GUIS	CANA	CAHA	ASIS	CACO	VIIS	DRTO	NATL
Nets	3	TR	1	TR	1	TR	1	4	2	1	1
Rope >1 m	9	6	111	4	2	1	2	9	154	5	5
Fishing line	14	TR	15	1	TR	TR	1	1	3	1	3
Loops	1	3	0	1	TR	0	TR	TR	TR	2	1
Closed straps	1	2	5	TR	TR	0	TR	1	2	TR	1
Gaskets	4	3	137	2	4	0	TR	3	49	3	2
Six-pack yokes	1	1	52	2	1	TR	TR	1	9	1	1
Total Mean	33	15	321	10	8	1	4	19	219	13	14
% Total Plastic Debris	2	2	2	5	1	< 1	3	2	6	3	2

Table 3. Types and average quarterly accumulation rates (number/km) of plastic ingestible debris at ten national parks in 1992-93. NATL is the average quarterly accumulation rate for all parks combined, except Padre Island National Seashore, Virgin Islands National Park, and Dry Tortugas National Park.

	OLYM	CHIS	PAIS	GUIS	CANA	CAHA	ASIS	CACO	VIIS	DRTO	NATL
Foam fragments	1520	251	3102	98	562	332	9	96	175	141	325
Plastic bags	25	34	683	16	10	13	23	105	134	9	48
Plastic sheets	15	11	2497	19	133	6	11	50	137	10	30
Balloons	1	12	115	5	14	4	15	60	12	1	21
Condoms	TR	0	1	TR	TR	0	0	0	0	0	TR
Total Mean	1561	308	6398	138	719	355	58	311	458	161	424
% Total Plastic Debris	78	39	40	41	56	87	41	32	12	39	49

Table 4. The ten most abundant plastic debris items found at ten national parks in 1992-93. National (NATL) ranks are based upon a non-parametric mean of ranks across the ten parks.

	NATL	OLYM	CHIS	PAIS	GUIS	CANA	CAHA	ASIS	CACO	VIIS	DRTO
Foam fragments	1	1	1	2	1	1	1	5	3	5	1
Hard fragments	2	2	2	1	2	2	2	8	4	1	2
Caps & lids	3	3	4	5	3	5	4	9	5	4	7
Bottles <1 gal	4	7	3	7	4	6	5	6	10	9	4
Bags <1 m sq	5	8	6	6	6	15	3	1	2	8	10
Rope <1 m	6	5	10	4	8	10	7	13	1	2	6
Sheets <1 m sq	7	13	13	3	5	3	6	4	8	7	8
Straws	8	31	5	9	11	4	12	7	9	3	22
Tobacco accessories	9	19	16	8	7	23	13	14	12	12	15
Balloons	10	38	11	12	10	8	9	2	7	20	36

Table 5. Comparative ranks of the ten most abundant plastic debris items for 1988-89, 1989-90, 1990-91, 1991-92, and 1992-93, and five-year average (excludes Padre Island National Seashore, Virgin Islands National Park, and Dry Tortugas National Park). Values in parentheses are the average quarterly accumulation rates (number/km).

	5 Year Average	1988-89	1989-90	1990-91	1991-92	1992-93
Foam Fragments	1 (276)	2 (111)	1 (218)	1 (241)	1 (325)	1 (435)
Hard Fragments	2 (97)	1 (128)	2 (85)	2 (111)	2 (92)	2 (71)
Caps & lids	3 (53)	6 (46)	3 (52)	3 (68)	3 (59)	3 (43)
Rope <1 m	4 (45)	5 (46)	4 (49)	5 (53)	4 (45)	6 (34)
Bottles <1 gal	5 (42)	4 (53)	6 (38)	6 (46)	6 (40)	4 (35)
Bags <1 m sq	6 (38)	3 (55)	7 (35)	8 (37)	7 (36)	8 (28)
Straws	7 (38)	7 (41)	5 (44)	7 (38)	5 (40)	7 (30)
Sheets <1 m sq	8 (35)	8 (30)	8 (27)	4 (58)	4 (28)	4 (35)
Balloons	9 (20)	9 (23)	9 (25)	9 (19)	9 (21)	9 (14)
Misc. packaging	10 (13)			10 (13)	10 (15)	14 (7)
Foam cups		10 (18)				
Food containers			10 (10)			
Fishing gear fragments						10 (11)

Appendix A: Data Forms

Marine Debris Survey Form

Surveyor ______________________ Location ____________ Location # ________ Beach # ____

Length ________ Transect ______ Substrate _____ Slope _____ Month _____ Day _____ Year _____ Cleared _____

Fishing Gear	1	2	3	4	5	6	7	8	9	10	T
*Trawl/seine web											
*Monofilament gillnet											
*Multifilament gillnet											
*Rope/line = >1m											
Rope/line <1m											
*Monofil. fish line											
Loops (rope)											
Open straps											
*Closed straps											
*Trawl floats											
*Gillnet floats											
*Crustacean pot floats											
*Buoy bags											
*Other floats											
Quart oil containers											
5-gal. oil container											
Fish basket											
Bait container											
Lures											
Chemical ampules											
Light stick											
Fragments											
Miscellaneous											

Personal Effects (Plastic)	1	2	3	4	5	6	7	8	9	10	T
Hats/helmets											
Footwear											
Gloves											
Tobacco accessories											
Toys											
Balloons											
Combs/brushes/eyeglas											
Tampon applicators											
Miscellaneous											

Plastic Packaging	1	2	3	4	5	6	7	8	9	10	T
Bottles <= 1 gal.											
Caps/lids											
Bags $<1m^2$											
Bags $=>1m^2$											
Plastic cups											
Styrofoam cups											
Styro food container											
Food contain/bowl/utsl											
Straws											
Pails/buckets											
Six-pack/beverage yoke											
Beverage crate											
Bulk liquid container											
Styrofoam packaging											
Miscellaneous											

Miscellaneous Plastics	1	2	3	4	5	6	7	8	9	10	T
Plastic sheet											
$<1m^2$											
$=>1m^2$											
Shotgun wads/shellcase											
Pipe/tubing											
Brushes/brooms											
Garbage cans											
Tires/innertubes											
Hard plastic fragments											
Foam fragments											
Pellets											
Gaskets/rings/etc.											
Miscellaneous											
Medical industry											
Offshore oil industry											
Petroleum: Slick/pancake/tar balls asphalt (presence=1, absence=2)											

* Complete data on measurement form

Marine Debris Survey Form

Page 2

Location # ____________ Beach # ____________ Date ___/___/___

Glass

	1	2	3	4	5	6	7	8	9	10	T
Bottles/jars											
Light bulbs											
Medical											
Pieces											
Miscellaneous											

Metal

Bottle caps	1	2	3	4	5	6	7	8	9	10	T
Propane canister											
55-gallon drum											
Beverage cans											
Other cans											
Wire/cable											
Crab/fish traps											
Pieces											
Miscellaneous											

Wood

Cloth

Stone

Leather

Paper

Location
01 – Olympic
02 – Channel Islands
03 – Padre Island
04 – Gulf Islands
05 – Canaveral
06 – Cape Hatteras
07 – Assateague Island
08 – Cape Cod

Beach
01
02
03
04
05
06

Transect (m)
01 = 0-100
02 = 1-200
03 = 2-300
04 = 3-400
05 = 4-500
06 = 5-600
07 = 6-700
08 = 7-800
09 = 8-900
10 = 9-1000

Substrate
1 Sand
2 Gravel
3 Boulder
4 Combination
5

Slope
1 Low
2 Moderate
3 Steep

Cleared
1 = yes
2 = no

If category is not used enter code (i.e. -9, -99, -999, etc.)

Total Beach Length ________ m

Transect lengths ________ m

Appendix B: Categories and Debris Recorded

Plastic Fishing Gear

Trawl/Seine Nets	Twisted or braided netting with 5 or more meshes intact. Measure knot to knot on one representative mesh stretched tight. Netting comprised of less than 5 meshes are tallied under fishing fragments and not recorded on the Plastic Measurement Form.
Monofilament Gill Net	Lightweight, single filament netting. Record in same manner as above.
Multifilament Gill Net	Lightweight, multistrand filament netting. Record in same manner as above.
Rope/Line	Twisted or braided. $\geq$ 1 m length - tallied and measured on both forms. $<$ 1 m length - tallied on survey form only.
Monofilament Fishing Line	Record on both forms if 1 m or more in length. Fishing lines $<$ 1 m are tallied under fragments only.
Loops of Rope	Rope spliced or tied together to form a loop. If article has a tail, consider it a rope and record as such.
Open Straps	Flat material used to band crates, boxes, bundles, etc. Tally on Survey Form only.
Closed Straps	Record on both forms. Measure stretch diameter.
Trawl Floats	Hard surface, hollow, usually with 2 or more eyes. Record on both forms.
Gillnet Floats	Small, elongated, rigid foam, grooved with 4 holes. Record on both forms.
Crustacean Pot Floats	Variable but usually rigid foam, tapered cylinder, minimum 15 cm diameter and 31 cm long; often marked with license number; consider large liquid containers with line attached to handle as this category. Record on both forms.
Buoy Bags	Spherical, inflatable, usually orange or red with one eye. Record on both forms.
Other Floats	Fishing bobbers, seine floats, boat bumpers, etc. Record on both forms.

Quart Oil Container	Two stroke, single weight or multiweight engine oil.
5-Gallon Lubricant Containers	Can or a pail with a lid and sometimes a spout or identifiable by label, residues, etc. If lid, residue and/or labels are absent, record as pail/bucket.
Fish Baskets	Similar to an oversized laundry basket.
Bait Containers	Usually quart-sized container with perforations or mesh.
Lures	Both rubber and plastic.
Chemical Ampules	About 500 cc, cubical, translucent, usually embossed with oriental characters. Usually found cut or torn open.
Light Sticks	Tubular, approximately 1 x 20 cm, sealed at both ends.
Fishing Gear Fragments	Net - all pieces with < 5 meshes intact. Fishing line - mono- and multifilament pieces < 1 m in length. Parts - any piece (< one-half size of original) of fishing gear that is identifiable as such.
Miscellaneous Fishing	Fishing articles that do not fit the above categories.

Plastic Personal

Hats/Helmets	Hard hats, assorted helmets, and headgear. Includes hats that have plastic webbing or fabric and plastic sun visors.
Footwear	Any footwear where at least one-half of the construction is of a plastic-/rubber base. Tongs, sandals, boots and shoes are included. An all-leather dress shoe with a rubber heel would not be included (it would be tallied under the Leather heading).
Gloves	Plastic and rubber base handwear including rubber-coated or impregnated materials. The exception is surgical gloves. These normally latex gloves are used for a variety of activities including the fishing industry, but because of the potential contamination by body fluids, they will be recorded as "medical" under the Plastic Miscellaneous heading.
Tobacco Accessories	Items associated with tobacco use. Includes lighters, snuff cans, pouches, pipe stems, cigar tips, etc.
Toys	Plastic and rubber.
Balloons	Plastic and rubber; colored ribbon was recorded under this category because our experience indicated that they were originally associated with balloons.

Combs/Brushes/Eyeglasses	Hair picks, barrettes, personal use brushes, including tooth, hair, shower, eyelash, etc. Eye glassware includes all types of glasses.
Miscellaneous Personal	Writing supplies, plastic papers, plants, ornaments, lifesaving rings, Q-tips, belts, diapers, etc.

Plastic Packaging Material

Bottles	All shapes, $\leq$ 1 gallon. Do not count caps or lids separately if on container.
Caps/Lids	Tally only those not on containers. Included in this category are broken beverage seals (such as from gallon water or milk jugs).
Plastic Bags	Count as a bag only if corner or seam is present (otherwise tally as a "plastic sheet").
Foam Food Containers	Foam, spongy, stiff or porous foam of a box-like shape, at least one-half original size.
Food Containers/Bowls/Utensils	All nonfoam articles.
Straws	Drinking straws or hollow coffee stirs.
Pails/Buckets	With or without bails.
Six-Pack/Beverage Yokes	Any device designed to hold beverage containers together.
Beverage Crates	Hard plastic boxes, usually with mesh and containing 12 bottles or cartons.
Bulk Liquid Containers	All containers > 1 gallon.
Foam Packaging	Molded packaging material recognizable as such and at least one-half of original size. "Peanuts/popcorn" are to be tallied as "foam fragments" under the Plastic Miscellaneous heading. The same holds true for any foam fragments that cannot be identified as to their function.
Miscellaneous Packaging	Candy bar wrappers, bottle labels, shrink wrap, etc.

Plastic Miscellaneous

Plastic Sheet	$\geq$ 1 m^2 - plastic sheets without seams or corners (wrapping, tarps, covers, visqueen).
	> 1 m^2 - same as above.
Shotgun Wads/Shell Cases	With or without brass base.
Pipe/Tubing	Rubber and plastic irrigation hose, PVC, etc.
Brushes/Brooms	Cleaning or maintenance type.
Trash Cans	Household or industrial garbage can.
Tires/Inner Tubes	Plastic or rubber vehicle tires or inner tubes of any size.
Hard Fragments	Rigid, nonfoam, nonporous pieces of unknown items or less than one-half of the original size, except for known fragments from the fishing or oil/gas industries.
Foam Fragments	Foam, spongy, stiff or porous foam of unknown origin or items less than one-half their original size.
Gaskets/Rings/Bands/Seals	All small closed rings, rubber bands, gaskets, safety seals, etc. Exceptions are for rubber bands used to enclose lobster claws; these items should be recorded as "miscellaneous" under the Fishing heading.
Medical Industry	Medical/health related items which may have come into contact with body fluids. Condoms, syringes, saline bags, plastic-based needles, etc.
Miscellaneous Plastics	Any item not fitting any of the above categories.

Appendix C

NATIONAL PARK MARINE DEBRIS MONITORING PROGRAM (1992-93):

PARK CONTACTS

Olympic National Park
Howard Yanish, District Ranger

Channel Islands National Park
Dan Richards, Marine Biologist

Padre Island National Seashore
John Miller, Chief, Resource Management

Gulf Islands National Seashore
Gail Bishop, District Interpreter (Mississippi District)

Canaveral National Seashore
Brian Carey, Chief Ranger

Cape Hatteras National Seashore
Ries Collier, Resource Management Biologist

Assateague Island National Seashore
Jack Kumer, Natural Resource Management Specialist

Cape Cod National Seashore
David Manski, Chief, Natural Resources Programs

Virgin Islands National Park
Jennifer Bjork, Resource Management Specialist

Dry Tortugas National Park
Scott Eckert, Chief of Interpretation